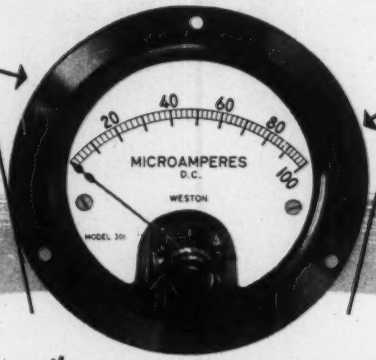
Instruments

HE MAGAZINE of MEASUREMENT and CONTROL

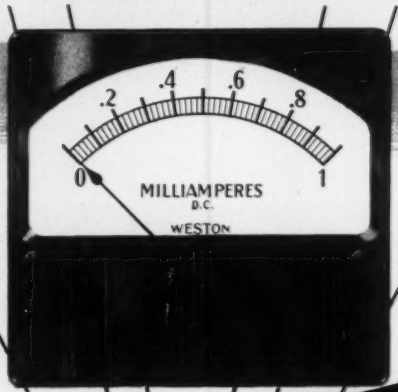
CLUDING THE *Journal of the Instrument Society of America*

D THE *Journal of the Southern California Meter Association*

INSTRUMENTATION OF A MODERN FOUR-ENGINE AIRLINER
UAL's Number One Pilot Captain Harry Huking (right) hears Captain L. R. Wagner comment on a new Boeing Stratocruiser (*See Page 136*).



"Built-in" OPERATING ASSURANCE



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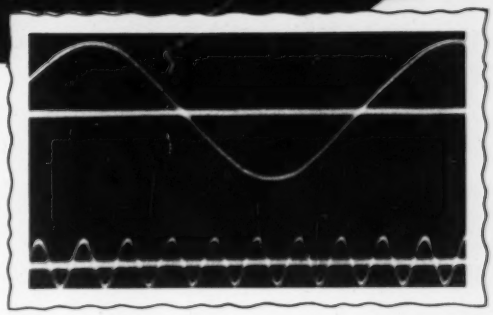

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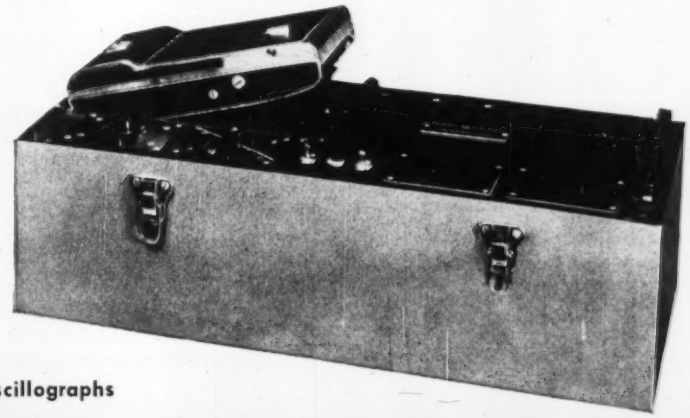

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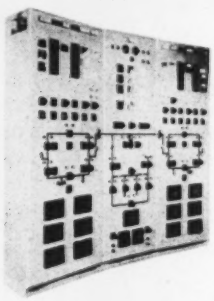

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Instruments

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

"WHY haven't you given as much as an inch of space to the IRE in *Instruments?*" asked a friend. We replied, "For the reason the milkmaid gave in the poem: 'No one has asked me to, sir,' she said."

"Well, I'm asking you now," said our friend, "I'm asking you to give space to our meeting and exhibit in New York next March; and I'm telling you that it will be the biggest technical gathering ever held; also that instrument papers will be featured at the technical sessions and instrumentation products at the show. The fact that you'll have a booth at the show proves that you realize it will be a big event for instrument-minded people. Don't print the program as a favor to me; print it for the benefit of your own subscribers. Those near New York will surely plan to come; those too far away will order copies of interesting technical papers; all will derive benefits."

It's a pleasure to comply! It's a pleasure also to do MORE than we were asked: to print the following extracts from a membership-drive leaflet:

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The Institute of Radio Engineers

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Hotel Commodore and Grand Central Palace, New York, N. Y., March 6, 7, 8 and 9, 1950

Technical Sessions (Hotel Commodore)

Monday Afternoon, March 6

Symposium: INDUSTRIAL DESIGN

"Evolution and Growth of Industrial Designing"—*J. Vassos*
"Procedure in Industrial Designing"—*C. Peterson*
"Cost Reduction Possibilities in Industrial Design"—*W. B. Donnelly*
"Sales Attitude towards Industrial Design"—*E. P. Toal*

Symposium: NUCLEAR SCIENCE AND THE RADIO ENGINEER

"News of the Nucleus"—*Urner Liddel*
"Particle Accelerators"—*M. S. Livingston*
"Radio Frequency Problems Associated with Particle Accelerators"—*J. P. Blewett*
"Detection of Nuclear Radiations"—*J. R. Dunning*

APPLICATIONS OF SEMICONDUCTORS

"Transistor Trigger Circuits"—*H. J. Reich and P. M. Schulteiss*
"Glass-Sealed Germanium Diodes"—*S. F. Amico*
"High Temperature Characteristics of Germanium Diodes"—*L. S. Pelfrey*
"Mathematical Theory and Applications of Silicon Crystals for Mixing and Harmonic Generation at Microwave Frequencies"—*P. D. Strum and J. W. Kearney*
"Considerations in Low Noise Figure Microwave Receiver Design"—*M. T. Lebenbaum and P. D. Strum*

SYSTEMS I—COMMUNICATION THEORY

"Representations of Speech Sounds and Some of Their Statistical Properties"—*Sze-Hou Chang, G. E. Pihl, and Martin Essigmann*
"Speech Transmission Through Restricted Bandwidth Channels"—*J. DiToro, W. Graham, and S. Schreiner*
"Application of Communication Theory to Periodic Radio Systems"—*M. Leifer and Nathan Marchand*
"Some Aspects of Data Transmission over Narrow Band Communication Circuits"—*M. Brenner*
"The Statistical Properties of Noise Applied to Radar Range Performance"—*S. M. Kaplan and R. W. McFall*

QUALITY CONTROL

"Accelerated Life Testing of Vacuum Tubes"—*J. Rothstein*
"Statistical Evaluation of Life Expectancy of Vacuum Tubes Designed for Long-Life Operation"—*E. M. McElvee*
"Application of Statistics to Acceptance Specifications"—*B. Kaslow*
"Statistical Methods in Research and Development"—*L. Lutzker*
"Statistical Engineering of Tolerances"—*E. D. Goddess*

Tuesday Morning, March 7

Symposium: ENGINEERING FOR QUALITY IN TELEVISION

"Top Management Evaluates Quality in Terms of Sound Engineering"—*Allen B. DuMont*
"Statistics—A New Tool for the Planning and Analysis of Laboratory Experiments"—*E. B. Ferrell*
"Specifications for Quality of the Visual Output of Picture Tube Screens"—*A. E. Martin*
"The Importance of Practical Design and Specifications for Effective Production and High Quality"—*J. Manuele*

Symposium: NETWORK SYNTHESIS IN THE TIME DOMAIN

"Comparison of Frequency and Time Domain Viewpoints in Circuit Design"—*W. H. Huggins*
"Study of Transient Effects by a New Method of Integral Approximation"—*M. V. Cerrillo*
"Applications of the Integral Approximation Method of Transient Evaluation"—*W. H. Kautz*
"Transient Response of Assymmetrical Carrier Systems"—*E. M. Williams and G. M. Anderson*

ANTENNAS I

"Waveguide Applications of Artificial Metallic Dielectrics"—*W. E. Kock*
"The Effects of Anistropy in a Three Dimensional Array of Conducting Discs"—*G. Estrin*
"A Study of Single-Surface Corrugated Guides"—*W. Rotman*
"A Study of the Current Distribution on the Helix"—*J. A. Marsh*
"Diffracted Beams in Metal Lenses"—*A. E. Heins*

SYSTEMS II—TRANSMISSION SYSTEMS AND RELAYS

"Signal Corps High Frequency Radio Communication Research and Development"—*John Hessel and H. F. Meyer*
"Military Single Sideband Equipment Development"—*R. A. Kulinyi*
"Radio Relay Design Data 60 to 600 Mc"—*R. Guenther*
"Multiplex Microwave Radio Relay"—*D. D. Grieg and A. M. Levine*
"Crosstalk in Frequency and Phase-Modulated Radio Relays Used in Conjunction with Multichannel Telephony Equipment"—*S. Fast*

MEASUREMENTS

"Oscillographic Presentation of Time Delay and Distortion in Broad Band FM Systems"—*A. R. Vallarino*
"Rockets Range Instrumentation"—*E. R. Toporeck and F. M. Ashbrook*
"New Test Equipment for the UHF Television Band"—*J. Ebert and H. A. Finke*
"Direct Reading Phasemeter"—*L. H. O'Neill and J. L. West*
"Measuring Procedure for Radioteletype Converters"—*H. C. Hawkins*

Tuesday Afternoon, March 7

TELEVISION I—TRANSMISSION SYSTEMS

"5 KW Visual and 2.5 KW Aural Television Amplifiers"—*P. Breen*
"Design Considerations in TV Transmitters"—*L. Pollack, E. Bradburd, and I. Krause*
"Wideband RF Problems in Television Transmitters"—*E. Bradburd and L. Pollack*
"The Vidicon—A New Photoconducting Television Pickup Tube"—*P. K. Weimer, S. V. Forgue, and R. R. Goodrich*
"Industrial Television System"—*R. C. Webb and J. M. Morgan*

PASSIVE CIRCUITS—FILTER CIRCUITS AND VARIABLE NETWORKS

"Frequency Analysis of Variable Networks"—*L. A. Zadeh*
"Distortion Bandpass Considerations in Angular Modulation Systems"—*A. A. Gerlach*
"Concerning the Lowest Possible Unloaded Resonant Circuit Q's which can be Used in Multiple Resonant Circuit Filters"—*M. Dishal*
"Tunable Microwave Waveguide Filters"—*W. Sichak*
"Filters for Television Interference"—*A. M. Seybold*

ANTENNAS II

"On the Relation Between the Geometry and the Impedance Characteristics of Typical Radiating Systems"—*I. H. Crowley and V. H. Rumsey*
"A Method for Studying the Response of Loops to the Electromagnetic Field"—*R. D. Dunn, Jr.*
"Measurement of the Radiation Efficiency of Elliptically and Linearly Polarized Antennas"—*J. H. Rowen*
"Broad Band Unidirectional Antenna 50 to 170 Mc"—*V. J. Colaguori and R. Guenther*
"Antenna System for Very High Frequency Radio Ranges and Direction Finding"—*F. J. Lundberg and F. X. Bucher*

SYSTEMS III—MODULATION SYSTEMS AND BAND-WIDTH REQUIREMENTS

"Product Phase Modulation and Demodulation"—*D. B. Harris and D. O. McCoy*
"Some Novel Methods for the Generation of PCM"—*N. R. Castellini, D. L. Jacoby, and B. Keigher*
"A High-Capacity Matrix-Commutated Radio Telemetering System"—*J. P. Chisholm, E. F. Buckley, and G. W. Farnell*
"Techniques for Closer Channel Spacing at VHF and Higher Frequencies"—*C. F. Hobbs and W. B. Bishop*
"Highly Selective Mobile Receiver"—*R. T. Adams, R. A. Felsenheld, and G. W. Sellers*

INDUSTRIAL INSTRUMENTS

"Use of Image Converter Tube for High Speed Shutter Action"—*A. W. Hogan*
"Ultrasonic Pulse Instruments for Automatic Continuous Measurement of Physical Properties of Solids and Liquids"—*S. R. Rich*
"Electronic Duplicator Attachments for Automatic Machine Tool Operation"—*W. Roth*
"Some Notes on Modern Methods of Servo Synthesis"—*R. McCoy and D. L. Herr*
"An Electronic Flowmeter and its Industrial Applications"—*E. Mittelmann and V. J. Cushing*

Tuesday Evening, March 7

Symposium: TELEVISION

A round table discussion of current television developments, including such items as color television and UHF allocation. The session will be presided over by Mr. Donald G. Fink as moderator.

ANTENNAS III

"Radiation from Circular Current Sheets"—*W. R. LePage, C. S. Roys, and S. Seely*
"Radiation Patterns of Circular and Cylindrical Arrays"—*J. E. Walsh*
"Properties of Guided Waves on Inhomegeneous Cylindrical Structures"—*R. B. Adler*
"Scattering of Plane Electromagnetic Waves by a Perfectly Conducting Hemisphere or Hemispherical Shell"—*E. Kennaugh*
"Diffraction by a Prolate Spheroid"—*F. V. Schultz*

Wednesday Morning, March 8

TELEVISION II—UHF AND COLOR TV

"A 1 KW UHF Television Transmitter"—*T. M. Glayas*
"A Supergain UHF Television Transmitting Antenna"—*O. O. Fiet*
"Design of a Hybrid Ring Diplexer for Ultra High Frequency Television Use"—*W. H. Sayer*
"Construction and Operation of an Experimental UHF Television Station"—*R. F. Guy*
"Electro-Optical Filters for Color Television"—*V. A. Babits and H. F. Hicks, Jr.*

COMPUTERS I—DIGITAL COMPUTERS

"Static Magnetic Pulse Control and Information Storage"—*An Wang*
"The Design of Diode Gate Circuits"—*R. J. Slutz*
"Marginal Checking as an Aid to Computer Reliability"—*N. H. Taylor*
"Development of the California Digital Computer"—*D. R. Brown and P. L. Morton*
"A New Class of Switching Tubes for Digital Applications"—*J. Katz*

ELECTRON TUBES I—THEORY AND DESIGN

"Monoformer"—*A. C. Munster*
"A New Type of Frequency Control Tube"—*R. W. Slinkman*
"M.I.T. Electrostatic Storage Tube"—*S. H. Dodd, P. Youtz, and H. Klemperer*
"Performance and Analysis of a Tranverse Current Traveling Wave Amplifier and Limiter"—*L. M. Field*
"An Experimental Electron Tube Using Space Charge Deflection of the Electron Beam"—*J. T. Wallmark*

ACTIVE CIRCUITS I—AMPLIFIERS

"The Analysis and Design of a Band-Pass Distributed Amplifier"—*V. C. Rideout and T. P. Tung*
"An Investigation of the 400-Megacycle Amplifier Performance of the Type SN-973B Subminiature R-F Pentode"—*N. B. Ritchey*
"An Extension to Stagger-Tuned Amplifier Design"—*J. M. Pettit*
"Ultra High Gain Direct Coupled Amplifier Circuits"—*W. K. Volkers*
"Analysis and Design of Self-Saturable Magnetic Amplifiers"—*S. Cohen*

Symposium: BASIC CIRCUIT ELEMENTS

"Performance—Measurement of Capacitors"—*H. T. Widhelm*
"Behavior of Resistors at High Frequencies"—*G. R. Arthur, H. L. Krauss, P. F. Ordung, and S. E. Church*
"Inductors, Their Calculations and Losses"—*R. F. Field*
"Transformer Performance and Measurements"—*Reuben Lee*

Wednesday Afternoon, March 8

TELEVISION III—RECEIVERS

"Use of Miniature Pentode RCA-6CB6 in Television Intermediate-Frequency Amplifiers"—*W. E. Babcock*
"Noise Suicide Circuit"—*H. E. Beste and G. D. Hulst*
"Quality Rating of Television Images"—*P. Mertz, A. D. Fowler and H. N. Christopher*
"Television Image Reproduction by Use of Velocity Modulation Principles"—*M. A. Honnell and M. D. Prince*
"Design of Printed-Circuit Television Tuner"—*D. Mackey and E. J. Sass*

ACTIVE CIRCUITS II—GENERAL

"Frequency Modulation Interference"—*L. B. Arguimbau*
"The Theory of Amplitude Modulation Rejection in the Ratio Detector"—*R. D. Loughlin*
"An Improved Method of Frequency Conversion"—*V. H. Aske and J. Grunad*
"Common Frequency Carrier Shift Radioteletype Converter"—*R. R. Turner*
"A Simple Crystal Discriminator for FM Oscillator Stabilization"—*J. Ruston*

ELECTRON TUBES II—THEORY AND DESIGN

"A New 'Soft Structure' for Rugged Receiving Tubes to Improve Resistance to Shock and Electron Emission"—*G. W. Baker*
"Hydrostatic Pressure in an Electron Gas: Its Application to Electron Beam-Electromagnetic Wave Interaction"—*P. Parzen and L. Goldstein*
"High Voltage Regulation by Means of Corona Discharge Between Coaxial Cylinders"—*S. W. Lichtman*
"Thyratron Grid Emission and the Trigger Grid Thyratron"—*L. Malter and M. R. Boyd*
"High Intensity Pulse-Distributing Tube"—*P. M. G. Toulon*

COMPUTERS II—INFORMATION ANALYSIS AND COMPUTING

"A Discussion Revealing Some Late Developments in Electronics Analog Computer Techniques"—*H. I. Zagor*
"An Electronic Storage System"—*E. W. Bivans and J. V. Harrington*
"Experimental Determination of System Functions by the Method of Correlation"—*J. B. Wiesner and Y. W. Lee*
"Measurement and Analysis of Noise in a Fire-Control Radar"—*F. H. Eisengrein*
"A Digital Electronic Correlator"—*H. E. Singleton*

TRANSMISSION AND ANTENNAS

"Surface-Wave-Transmission Lines"—*G. Goubau*
"FM Distortion in Linear Systems having Small Sinusoidal Irregularities in Transfer Characteristics, with Application to Lossless Waveguides"—*F. Assadourian*
"The Representation, Measurement, and Calculation of Equivalent Circuits for Slots in Rectangular Wave Guide"—*J. Blass, L. Felsen, A. A. Oliner, H. Kurss, and N. Marcuvitz*
"Dielectric Tube Antennas"—*R. E. Beam and D. G. Harman*
"Measurement of Current and Charge Distributions on Antennas and Open-Wire Lines"—*D. J. Angelakos*

Thursday Morning, March 9

AUDIO—TRANSDUCER DESIGN

"Sound System Design for Reverberant Auditoriums"—*L. L. Beranek, W. H. Radford, and J. B. Wiesner*
"High Efficiency Loud Speakers for Personal Radio Receivers"—*H. F. Olson, J. C. Bleazey, J. Preston, and R. A. Hackley*
"A Review of Direct Radiator Loudspeakers"—*F. H. Slaymaker*
"Loudspeaker Housings"—*W. F. Meeker*
"A Miniature Condenser Type Microphone"—*J. K. Hilliard*

ELECTRONICS IN MEDICINE

"Effects of Intense Microwave Radiation on Living Organisms"—*J. W. Clark*
"A Differential Vectorcardiograph"—*S. A. Brüller and N. A. Marchand*
"Electronic Mapping of the Electrical Activity of the Heart and Brain"—*S. Goldman*

PROPAGATION I—PROPAGATION AT IONOSPHERIC FREQUENCIES

"Calculation of Effective Phase, Group, and Pulse Velocities of Wave Propagation"—*A. Fischler, G. H. Sloan, and D. Goldenberg*
"An Atmospheric Wave Form Receiver"—*W. J. Kessler and S. E. Smith*
"Radio Wave Propagation in a Curved Ionosphere"—*J. M. Kelso*

ELECTRON TUBES III—POWER TUBES

"Development of 10 cm High Power Pulsed Klystron"—*M. Chodorow, E. L. Ginzton, I. Neilsen, and S. Sonkin*
"Space Charge Effects in Reflex Klystrons"—*V. Westberg and M. Chodorow*
"Recent Development in High-Power Klystron Amplifiers"—*C. Veronda and V. Learned*
"A New Super-Power Beam Triode"—*W. N. Parker, W. E. Harbaugh, M. V. Hoover, and L. P. Garner*
"External Cathode Inverted Magnetron"—*J. F. Hull*

NAVIGATION AIDS

"Analysis of Course Errors in the VHF Omni-directional Radio Range"—*J. Wesley Leas*
"Dynamic Aspects of Errors in Radio Navigation Systems Particularly in Case of Fast Moving Receivers or Transmitters"—*H. Busignies*
"A New Basis for Analyzing Radio Navigation and Detection Systems"—*N. L. Harvey*
"Stochastic Processes as Applied to Aerial Navigation and Direction Finders"—*L. A. DeRosa*
"1000 Mc Crystal-controlled Airborne Transmitter"—*B. Warriner*

Thursday Afternoon, March 9

Symposium: SOUND RECORDING

"Noise Considerations in Audio Systems"—*F. L. Hopper*
"Considerations of Noise in Sound Recording and Reproducng Systems"—*A. W. Friend*
"Magnetic Recording Frequency Response-Measurement Procedures and Pitfalls"—*R. E. Zenner*
"Distortions in Recording Systems"—*H. E. Roys*
"Perceptibility of Flutter in Recorded Speech and Music"—*H. Schaefer*

PROPAGATION II—THE IMPACT OF PROPAGATION ON OPERATIONAL SYSTEMS

"A Microwave Propagation Test"—*J. Z. Millar and L. A. Ryam, Jr.*
"Diversity Reception Techniques"—*S. H. Van Wambeck and A. H. Ross*
"Experimental Evaluation of Diversity Receiving Systems"—*J. L. Glaser and S. H. Van Wambeck*
"Comparison of Modulation Methods for Voice Communication over Ionospheric Radio Circuits"—*M. G. Crosby, H. F. Meyer, and A. H. Ross*
"Comparison of Modulation Methods for Facsimile Communication over Ionospheric Radio Circuits"—*M. Acker and B. Goldberg*

ELECTRON TUBES IV—MATERIALS AND TECHNIQUES

"A Vacuum Seal Between Metals and Ceramics for High Temeprature Applications"—*H. W. Soderstrom and K. H. McPhee*
"Effect of Coating Composition of Oxide-Coated Cathodes on Electron Emission"—*E. G. Widell and R. A. Heller*
"Effects of Controlled Impurities in Nickel Core Metal on Thermionic Emission from Oxide-Coated Cathodes"—*G. Heex*
"Investigation of Contaminants in Vacuum Tubes"—*P. D. Williams*
"Hot Strength Properties of Filamentary Alloys"—*B. Wolk*

COMPONENTS

"Miniaturization Techniques: A Discussion and Proposal"—*M. Abramson and S. Danko*
"The Exponential-line Pulse Transformer"—*E. R. Schatz and E. M. Williams*
"Universal Precision Resolves"—*D. L. Herr*
"A Compact Magnetic Memory"—*P. L. Morton*
"Synchro-Cyclotron Field Regulator"—*C. S. McKown and W. P. Caywood*

OSCILLATORS

"The Transient Behavior of a Class C Oscillator"—*C. H. Page*
"Mode Suppression in Broadband Reflex Klystron Oscillators"—*A. H. Sonnenschein and H. A. Finke*
"Telemetering Blocking Oscillator"—*W. Todd*
"Some Aspects of R-F Phase Control in Microwave Oscillators"—*E. E. David, Jr.*
"Seven League Oscillator"—*F. B. Anderson*

ANNUAL MEETING OF THE INSTITUTE

Monday, March 6, 10:30 A.M.
Luncheon Speaker: Dr. Ralph Brown

RADIO ENGINEERING SHOW HOURS

Grand Central Palace, 46th Street and Lexington Avenue, New York City
Monday, March 6, 9:30 A.M. to 9 P.M.
Tuesday, March 7, 9:30 A.M. to 9 P.M.
Wednesday, March 8, 9:30 A.M. to 6 P.M.
Thursday, March 9, 9:30 A.M. to 6 P.M.

IRE TECHNICAL AND STANDING COMMITTEES

Monday through Thursday. For details see February Issue of PROCEEDINGS of the I.R.E.

SOCIAL CALENDAR

"Get together" Cocktail Party
Monday, March 6, 5:30-8:30 P. M. at The Hotel Commodore
President's Luncheon
Tuesday, March 7, 12:45 P.M. at The Hotel Commodore
IRE Annual Banquet
Wednesday, March 8, 6:45 P.M. at The Hotel Commodore

EXHIBITORS AT THE 1950 RADIO ENGINEERING SHOW

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Acro Transformer Co., Long Island City, N. Y.—363
Advance Electric & Relay Co., Los Angeles, Calif.—135
Aerovox Corp., New Bedford, Mass.—124
Aircraft-Marine Products, Inc., Harrisburg, Pa.—273
Alden Products Co., Brockton, Mass.—R
Alfax Paper & Eng. Co., Brockton, Mass.—305
Allied Control Company, Inc., New York, N. Y.—279
Allied Electric Products Inc., Irvington, N. J.—326
Altec Lansing Corp., New York, N. Y.—V
American Chronoscope Corp., Mt. Vernon, N. Y.—X
American Lava Corp., Chattanooga, Tenn. —55
American Phenolic Corp., Chicago, Illinois—111 & 112
American Structural Products Co., sub of Owens-Illinois Glass Co., Toledo, Ohio—96
American Television & Radio Co., St. Paul, Minn.—202
Amperex Electronic Corp., Brooklyn, N. Y. —10, 11 & 12
Amphenol Corp., Div., Gen. Precision Equip. Corp., Chicago, Ill.—F
Antara Products, Gen. Aniline & Film Corp., New York, N. Y.—28
Applied Science Corp. of Princeton, Princeton, N. J.—356
Askania Regulator Co., Div., General Precision Equipment Corp., Chicago, Illinois—F
Atomic Instrument Co., Boston, Mass.—243
Audio Devices, Inc., New York, N. Y.—231
Automatic Electric Sales Corp., Chicago, Ill.—290
Ballantine Labs., Inc., Boonton, N. J.—100
Barker & Williamson, Inc., Upper Darby, Pa.—C
Barry Corp., Cambridge, Mass.—285
Beam Instruments Corp., New York, N. Y.—251
Bendix Aviation Corp., Baltimore, Md.—15, 16 & 17
Bendix Aviation Corp., Eclipse-Pioneer Div., Teterboro, N. J.—15, 16 & 17
Bendix Aviation Corp., Scintilla Magneto Div., Sidney, N. Y.—15, 16 & 17
Bendix Aviation Corp., Eed Bank Div., Red Bank, N. J.—15, 16 & 17
Bendix Aviation Corp. (Pacific Div.), N. Hollywood, Calif.—15, 16 & 17
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Bird Electronic Corp., Cleveland, Ohio—238
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W. H. Brady Co., Milwaukee, Wisc.—228
William Brand & Co., New York, N. Y. and Chicago, Illinois—84B & 85
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Continental Carbon, Inc., Cleveland, Ohio —244
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Measurement *and* Control Problems *in* Typical FIXED-BED CATALYTIC PROCESSES

By A. W. HOGE, G. F. HORNADAY and C. O. WALLS, Jr., Houdry Process Corp., Philadelphia, Pa.

Introduction

In terms of the complexity of measurement and control, it may be generalized that there are three types of fixed-bed catalytic processes. The simplest of these is a process in which a single fluid, or single mixture of fluids, flows continuously through the reactor section. Next in complexity is an intermittent process with cyclic changes in the quantity and/or type of fluid flowing through an individual reactor but operating on a long time cycle of several hours' duration. Lastly, an intermittent process on a short time cycle would normally be expected to be the most complex of the three because of the variety of flowing fluids and the frequent valve movements required to divert the flows.

Often, control of the continuous or non-cyclic catalytic process may not differ from the control of a simple non-catalytic process system. However, it frequently is desirable to add special instrumentation to such a system for the purpose of protecting and extending the useful life of the catalyst.

The intermittent or cyclic fixed-bed catalytic processes are generally arranged with a multiplicity of reactors so that, in effect, the principal flows of reactants and products are made continuous through a scheduled sequential operation of the reactors. As examples of intermittent processes operating on long-time cycles, there are the Hydro-forming and Cyclo-version processes in the petroleum industry. In these processes it is necessary, periodically, to stop the flow of hydrocarbon feed through the catalyst bed and using air, steam, flue gas or a combination of such non-hydrocarbon vapors, conduct a regeneration of the catalyst to remove heavy hydrocarbon residues and coke and thereby restore catalytic activity. It is to be expected that more automatic controllers would be included in a system of this type than in the continuous system first mentioned. Illustrative of the short cycle, intermittent fixed-bed process is the Houdry Fixed-Bed catalytic cracking process. In this process it is necessary to regenerate the catalyst after an on-stream period of about ten minutes. Owing to the short cycle time, the frequency of valve operations and the variety of flowing media required in the operation, special instrumentation is needed in order to maintain a minimum number of men in the operating crew. Since by its nature a process such as this presents the greatest opportunity for unique and interesting instrumentation, it is intended to discuss the highlights of the instrumentation in the reactor section of a Houdry plant.

In the pilot and semi-commercial plant development of the process, the reactors were actually manually controlled. As process considerations became better developed, however, it was obvious that before the process could be commercialized, many mechanical problems had to be solved. Suitable mechanized valves would have to be designed and special instrumentation would need to be provided before construction of a commercial plant could even be considered. That the initial solution of these instrumentation problems was extremely successful is evidenced by the fact that the essential instrumentation of original plants remains substantially unchanged today after as many as thirteen years of steady, dependable operation. This is all the more remarkable when it is considered that several major items of the plant equipment were either designed specifically for Houdry units, or their installation marked the first large-scale use of such equipment. Reduced to fundamentals, none of these special items was absolutely novel, but for the special requirements of the process, completely acceptable forms of the equipment were not available and these had to be developed for the commercialization of the process.

To name major items in this category, there is the cycle timer for the completely automatic control of approximately 35 motor-operated valves. The timers most generally used have 900 contact points. This number of contacts permits successive operations at intervals as short as 1½ seconds. Large size motor-operated valves for high-temperature service, which can withstand frequent opening and closing operations at relatively fast speeds, and which incorporate certain safety features, are absolutely essential. Turbo-compressor units that function 24 hours a day for months at a time are also essential to the process and had to be developed to perform within the limits of the process requirements.

General Description of Process

To facilitate an understanding of the basic instrumentation, a few words descriptive of the process, are in order. The Houdry Fixed-Bed plants (Fig. 1), depending on size, operate at oil feed rates from 5000 to 25,000 bpsd., with corresponding regeneration air rates from 16,000 to 60,000 scfm. A molten salt cooling medium is circulated through

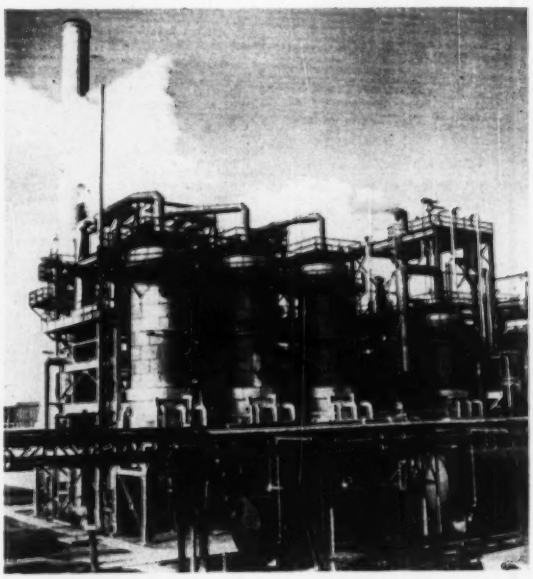


Fig. 1

the reactors at rates from 10,000 to 35,000 gpm. The reactors are essentially vertical tubular heat exchangers with catalyst on the shell side. Cooling medium flows through some of the tubes while other tubes are equipped with orifices in the tube walls to provide for uniform distribution and withdrawal of vapors in all portions of the catalyst bed. A pipe manifold at the top and bottom of each reactor connects the reactor with the headers carrying each of the process streams, such as oil vapor, regeneration air, purging steam, etc. A motor-operated valve is installed at each of these manifold connections to divert the proper stream to each reactor at the appropriate time (Fig. 2).

The cyclic sequence of operation of the reactors may be described briefly as follows: The normal total cycle time is 30 minutes. In other words, every 30 minutes the complete sequence of on-stream period, oil purging, regeneration period and air purging is repeated on each reactor (Fig. 3). Normally the on-stream and regeneration periods are ten

* Presented at Short Course on "Instrumentation for the Process Industries," Texas A & M College, Oct. 12-14, 1949.

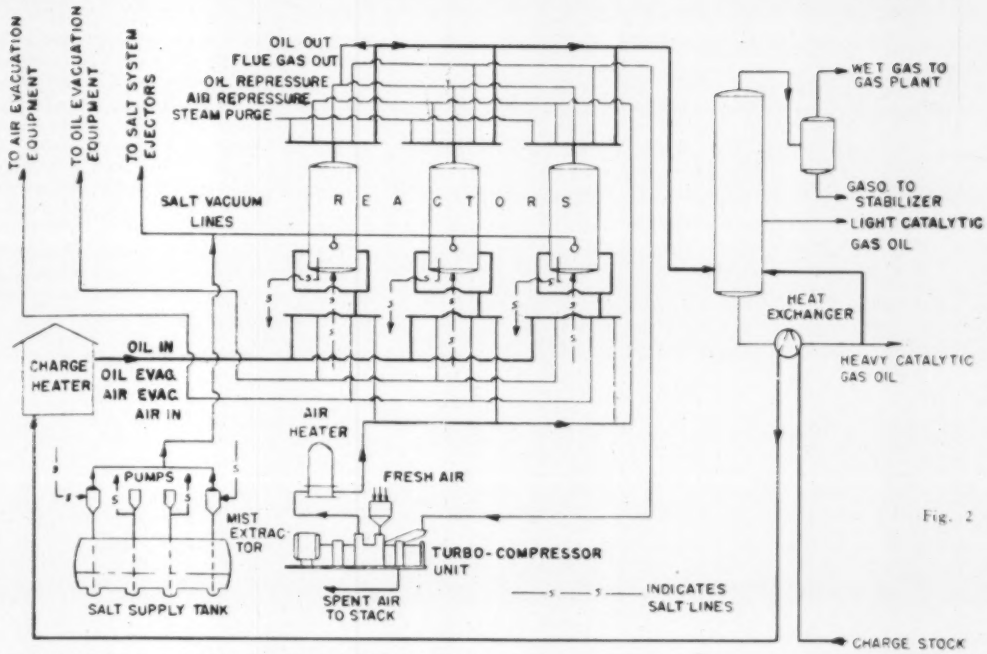


Fig. 2

minutes each and the remaining ten minutes are consumed in the purging operations. It is apparent, then, that three reactors or multiples of three reactors are required in order to provide continuity of flow of the process streams. While one reactor is on stream, a second is regenerating and the third is being prepared for either an on-stream or regeneration period.

Automatic Regulation of Cycle Sequence

To regulate automatically the material that is to flow to or from a given reactor as well as the time of flow, an electrical cycle timer is employed. Several types of electrical timers, similar in principle but differing in structural arrangement, have been used on Houdry units. The type installed most recently will be described (Fig. 4).

At the rear of the timer dial are 900 contact points arranged in five concentric circles of 180 contacts each (Fig. 5). Five brushes, one for each circle, sweep the contact points as the timer arm rotates at constant speed. There is no overlap between the points, only one point being in contact with a brush at any given instant. On a 30-minute cycle this is equivalent to two seconds between contacts. The timer arm drive mechanism consists of a clutch and two motors so that if a motor should fail, a push or pull of the clutch lever will engage the spare motor and quickly restore the timer operation. Each motor is also provided with a set of gears which enables the cycle time to be changed from 20 minutes to 60 minutes in increments of 2 minutes. Thus, while one motor is driving the timer to give one revolution in 30 minutes, the gears may be set up on the opposite motor for some other length of cycle. Then the first motor may be disengaged through the clutching mechanism, the second motor immediately engaged and the plant continued in operation on a decreased or increased time cycle. An important detail is the impulse counter mounted on the timer control panel. Three digit wheels carry numbers from 1 to 900. The counter is geared directly to the timer arm drive mechanism and is, therefore, always a true indication of the exact point that is in contact with a timer arm brush.

In order to have complete flexibility in arranging any desired cycle sequence, a terminal board is provided with jack plugged jumpers from each contact of the timer dial to each timer operated device (Fig. 6). These jumper wires may be plugged in to any terminal chosen at this board and will then be in the circuit corresponding to the same contact number on the cycle timer. In this way it is possible to make minor revisions in the sequence of operation without stopping the timer or interfering with its operation in any way.

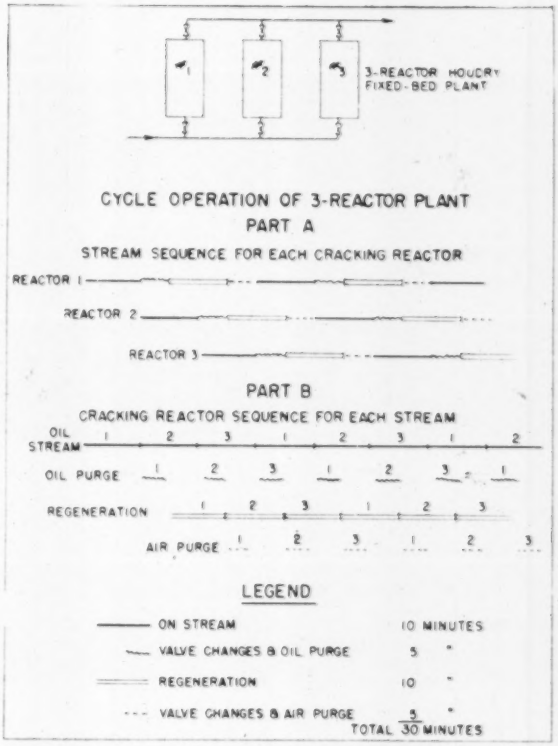


Fig. 3

The primary function of the timer is to give the electrical impulse that will energize the relay causing a 440-volt motor circuit to open or close a valve in the reactor area. About 3 seconds after a valve operation should have been completed, another timer contact in the valve position test circuit verifies that the valve operation has been completed (Fig. 7). If the valve did not fully open or fully close, the timer will stop automatically and an alarm will sound. By referring to the impulse counter and sequence chart, the operator can readily identify the failure and correct it manually or, preferably by manual electrical remote con-

trol employing the switches and buttons located adjacent to the timer case.

The test circuits are designed to prevent operations getting out of phase. For example, the oil outlet and oil inlet valves on one reactor are tested open before the oil inlet and oil outlet valves of the next reactor are permitted to close. This prevents a complete blockage of oil flow through the plant. Similarly, the air valves on a given reactor must be tested open before the air valves of the reactor completing regeneration are permitted to close. Otherwise, the output of the axial air compressor would be blocked with the possibility of damage to the compressor. Any number of such test circuits may be established for the purpose of safeguarding the system.

The foregoing applies to the completely automatic operation of the timer and motor-operated valves. There are certain valves that may be operated manually even while the timer is in motion. However, if the manual operation of any valve during certain phases of automatic timer operation would create a hazard, these valves are electrically interlocked to the system in such a way that their switches and push buttons are electrically inoperative.

Regulation of Flow Distribution—The Motor-operated Valve System

As previously mentioned, motor-operated valves capable of withstanding extreme service conditions are a prerequisite to successful plant operation. These valves are 300-lb.

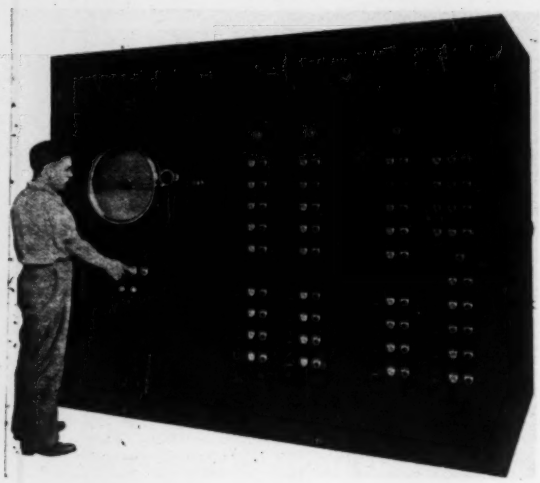


Fig. 4

(Series 30) specified for 900 F. maximum temperature and able to withstand an opening or closing operation every 5 minutes. The body and bonnet are cast carbon molybdenum steel. They have a tee head type solid wedge disk with seating surfaces coated with No. 6 Haynes Stellite. The seat rings are the renewable bottom seated type of carbon molybdenum steel with seating surfaces of No. 6 Haynes Stellite. Valve stems are 11-13 percent chrome steel, the unthreaded portion being ground and polished. Brinell hardness of the threaded portion of the stems is specified to be 280 to 325. Valve sizes from 4 to 18 inches have been used. The valves are equipped with actuators so designed that the electric motor attains full speed before it starts to drive the operator gears and thereby applies a hammer blow which aids in freeing the disk from the seat in the valve opening operation (Fig. 8). A clutch and hand-wheel are provided for manual operation of the valve. After any manual operation, the hand-wheel is automatically disengaged and the motor is automatically engaged to the drive gears when a starting impulse is given to the motor.

In the upper part of the actuator housing is a drum switch capable of making or breaking 12 circuits (Fig. 9). In general, only a portion of the 12 contacts is used. The auxiliary valve stem which is screwed into the main valve stem plus two ball cams actuates the drum switch through mechanical linkages. Contact with one of these cams causes the linkages to rotate the drum switch approximately 30 degrees clockwise from a neutral position. Contact with the other cam causes the drum switch to rotate counter-clockwise from the neutral position. Two of the drum switch contacts operate the red and green lights in the control room which indicate the valve open and closed positions, respectively. In intermediate positions of the valve travel, both the red and green lights are lighted. The valve must be within ¼ inch of fully-opened or fully-closed for only one colored light to show. Another contact serves as an opening limit switch and determines the power cut-off point for motion of the valve in the opening direction, so that the motor is protected and the back seating bushing on the stem is not driven hard into its seat. Two more contacts are in the open test and closed test circuits of the cycle timer. If a valve is not within ⅛ inch of fully-seated or fully-opened when tested for that position, the test circuit will be closed actuating the relay that will stop the timer drive motor. In such an event, an audible alarm sounds in the control room

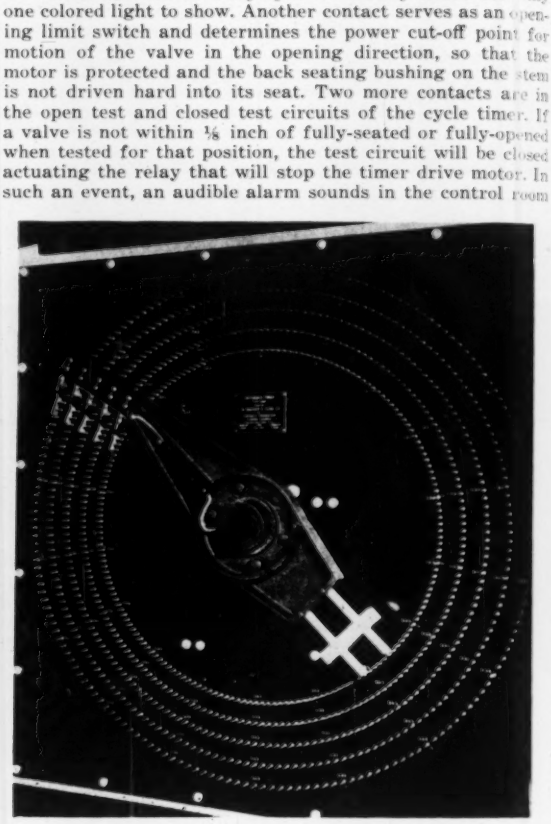


Fig. 5

and the timer may not be restarted until the trouble is cleared. Two more contacts of the drum switch are used in interlock circuits by means of which improper automatic or improper manual electrical operation of a valve is prevented. It is by this system of interlocked circuits, for example, that oil valves and air valves can never be opened electrically on one reactor at the same time. The reasons for such protective measures are obvious.

The closing limit switch mounted on the side of the valve actuator unit is in reality a torque switch. The worm splined to the motor-driven shaft moves along this shaft compressing the torque spring as the valve disk is driven into its seat. The worm follower contacts the torque switch arm, causing the switch to open and de-energize the motor driver. This particular switch may be adjusted over a considerable range of torque for light to heavy seating.

In general, each reactor has nine timer-controlled motor-operated valves. In addition, about eight other valves on auxiliary equipment, such as steam and water lines to evacuation equipment, are operated by the timer. Reactor valves open and close once every 30 minutes. Some of the auxiliary valves are opened and closed three times every 30 minutes. In addition, there are some motor-operated valves that may be operated electrically from the control room but

that are not connected in any way with the cycle timer. The main oil inlet, main oil outlet, and oil by-pass valves are in this category. The actuators for these valves are generally geared to require 60 seconds to open or close. All the other motor-operated valves in the reactor system are designed for 9-second opening or closing.

As already mentioned, the reactors are protected electrically against improper operation of a valve. As a further check against possible mixing of streams, the valves are provided with connections through which steam is admitted to envelop the valve gate in the closed position with a blanket of steam. The pressure on this blocking steam system is maintained at least 10 pounds higher than the pressure on the air or oil lines to the reactor. Therefore, if any leakage should occur through a closed valve, it will be steam into air or oil and never leakage of oil into air or air into oil. A third and larger ball cam on the auxiliary stem of the motor-operated valve contacts the linkage which actuates the half-inch valve on the blocking steam line. As the motor-operated valve moves near the closed position, this cam contacts the linkage which opens the blocking steam valve. Some plants have installed a recording flow meter on the supply header of the blocking steam system.

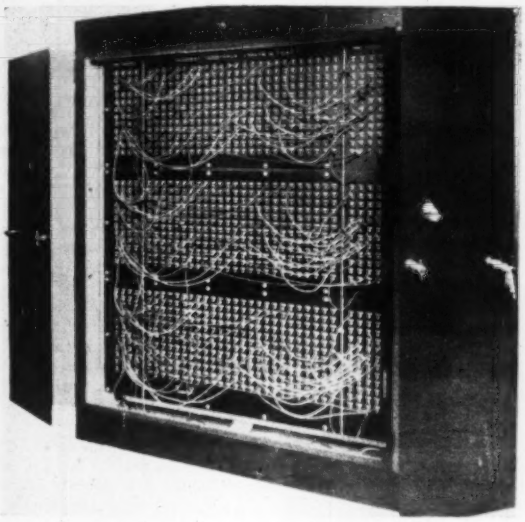


Fig. 6

In this way a printed record indicative of the blocking steam requirements is obtained. An excessive steam demand would indicate incomplete seating of one or more valves. By observing the time at which excessive blocking steam was required and relating it to the sequence chart, the valve that was not seating tightly may be located.

Temperature Regulation

Temperature control in a Houdry Fixed-Bed unit does not present any particular problems in spite of the cyclic nature of the process. Indeed, no automatic temperature control instrumentation is used. This is possible by virtue of the molten salt heat transfer system which is an integral part of the internal design of the reactors. On a standard 6-reactor Houdry unit, a 17,000-gpm. pump circulates molten salt continuously through all reactors as well as auxiliary heat exchange equipment. At operating temperatures in the neighborhood of 800 F. the salt has a specific gravity of about 1.77 and a specific heat of about 0.37. Although in a plant of this size the heat liberated each hour by the regeneration of the catalyst amounts to about 100,000,000 Btu., the heat capacity of the flowing salt is such that temperature variations are very nominal. Normally, the maximum differential between the inlet and outlet salt temperatures on a given reactor is about 30 F.

Having absorbed heat in passing through the reactors, the salt returns to a reservoir tank from which the circulating pump takes suction. The temperature of the salt in this tank is held constant by diverting a small portion of the salt pump discharge to two pieces of heat exchange equipment, a salt-steam boiler and a regeneration air preheater, in which the net exothermic heat from the process is absorbed. Regulation of the temperature of the circulating salt (and, hence, the temperature of the entire system) is achieved by manually controlling the rate of salt flow to the salt-steam boiler. For example, if it is desired to raise the temperature on the reactor system, a slight adjustment in the closing direction on the salt valve to the boiler is made. A single-point temperature recorder is provided to aid the operators in the control of the salt temperature. This instrument has an expanded scale chart, one-tenth of an inch on the strip chart being equivalent to 2 F. The temperature of the salt at the circulating pump discharge is generally held within 2 F. of specification without difficulty. As a matter of fact, the process is sensitive to very small changes in temperatures as evidenced by changes in product distribution and it has proved practical to specify changes of as little as 2 F. on the salt temperature.

Pencil-type thermocouples are used in the catalyst bed. They are inserted into stainless steel protecting tubes and normally there are six catalyst thermocouples for each reactor. These are located at various levels and various dis-

PORTION OF CYCLE TIMER SEQUENCE CHART
(SEVERE CYCLE)

Impulse No.	Operation	Regular No.	Time Seconds
302	Open Oil Outlet	2	6
303	Open Oil Inlet	1	4
308	Test Open Oil Outlet	2	16
309	Test Open Oil Inlet	1	14
311	Close Oil Inlet	1	10
312	Close Oil Outlet	1	20
317	Test Close Oil Inlet	1	14
318	Test Close Oil Outlet	1	12
319	Open Oil Evacuation	1	34
325	Test Open Oil Evacuation	1	16

Fig. 7

tances from the center of the reactors to provide an average record of internal temperatures.

Air temperature regulation presents no problem since the flow of regeneration air through the system is essentially constant and ordinarily there is no occasion to change the inlet air temperature. Fresh air from the compressor passes through the salt-air exchanger where it is preheated to approximately 800 F. before entering the reactors.

The Houdry Fixed-Bed process is capable of processing only vaporized feed stocks. In fact, to avoid possible damage, it is absolutely essential that no liquid oil ever reach the reactors. Protection against such a hazard is provided in a special control circuit. A thermocouple with indicating controller in the vapor transfer line from the furnace is designed to energize the circuits which will consecutively and automatically open the main oil by-pass valve around the reactors, close the main oil inlet valve, and sound an alarm on low oil transfer line temperature. The indicating controller is set to perform these operations at about 25 F. above the calculated dew-point of the reactor charge at the flowing conditions.

Pressure Regulation

The minimum reaction zone pressure during the cracking phase is determined by the back pressure of the system following the reactors and normally is 8 to 10 psig. On some plants additional back pressure is imposed and controlled by a conventional back-pressure regulator on the fractionator following the reactors. Actually, owing to change in the rate of the cracking reaction during a 10-minute on-stream period, and owing to the repressuring of the next reactor to come on-stream with synthetic crude vapors, there is a

Continued on page 174

Instrumentation Requirements *for* AIRLINE AIRCRAFT

By R. D. KELLY, Sup't of Technical Development, United Air Lines, Chicago, Ill.

TODAY'S TRANSPORT airplane is the most highly instrumented transportation medium in existence. This has not always been true, inasmuch as the early airplanes were equipped with but few instruments, the quality of which did not compare with those now in use. Whereas the original commercial mail and passenger airplanes were flown with only four or five instruments, a modern United Mainliner 300 mounts 83 individual instruments on its pilot's instrument board. Of these 83 instruments, 25 are dual indicators wherein two separate pointers indicate two separate conditions. It is obvious that this doubling up has been necessary in order to conserve instrument-board space.

*Presented before the Chicago Section, Instrument Society of America, November 1, 1949.

In addition to these instruments—those that have been counted—others are utilized through-out the airplane to measure the condition of the cabin heating and ventilation systems and various other functions. The Mainliner Stratocruiser, the latest addition to United's fleet, has a still greater number of instruments.

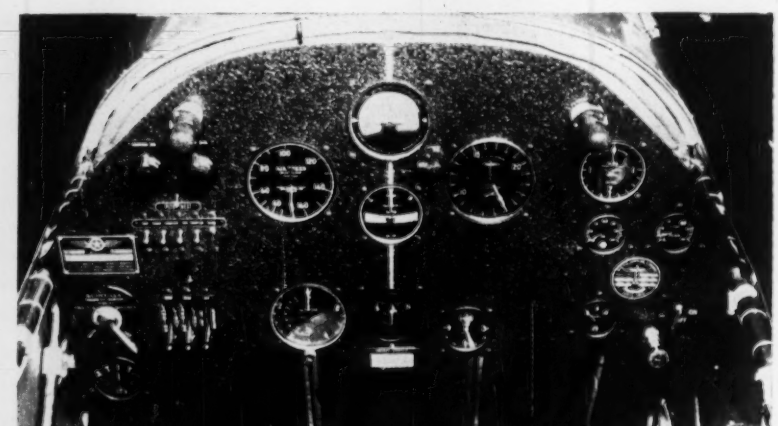
Such a large number of instruments is a measure of the great complexity of the modern commercial transport airplane. Without adequate instrumentation it would be absolutely impossible to operate a modern transport airplane safely, on schedule, under all conditions of weather and over all terrain. No other transportation medium depends so largely upon instrumentation. No other means of transportation requires so many varied and automatic controls with matching instrumentation so it can be maintained on a proper course, in a proper attitude and at a desired altitude under all atmospheric conditions.

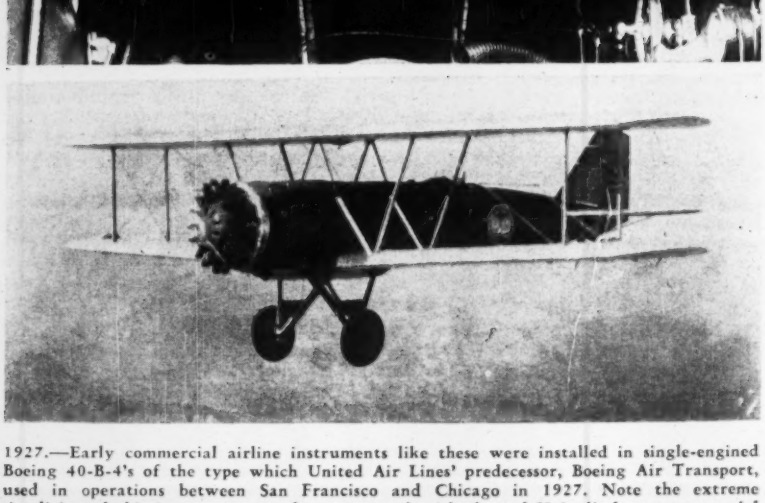
Lord Kelvin's oft-quoted dictum that "to measure is to know" must be amplified to bring home the fact that an adequate number of measurements must be taken of all the various functions. To measure but one variable can lead to exceedingly false conclusions. A little knowledge can be a dangerous thing. Oftentimes the simultaneous measurement of two or three, or four or five, variables is not sufficient. This, I think, has been amply demonstrated in our aircraft.

When instruments first began to be taken seriously by airplane pilots and engineers, one of the chief difficulties was that of impressing upon the pilots the fact that they must not rely upon any one or two instruments alone, but that the indications of several instruments must be properly coordinated and integrated so as to obtain a good interpretation of the events taking place. In those early days almost every pilot had his favorite instrument. Some of them relied chiefly upon the airspeed indicator. Others relied upon the tachometer. Still others preferred to concentrate attention upon the compass, the turn indicator or the altimeter. When it was pointed out to them that they must read and interpret all of these instruments almost simultaneously, many of them would flatly state that it was humanly impossible. It was not unusual to find pilots with considerable experience stating that "blind" or "instrument" flying would never be possible for more than very short intervals and that they would never resort to it, except in an emergency in an effort to get themselves out of trouble. It cost many lives and much hard experience to demonstrate the fallacy of such thinking.

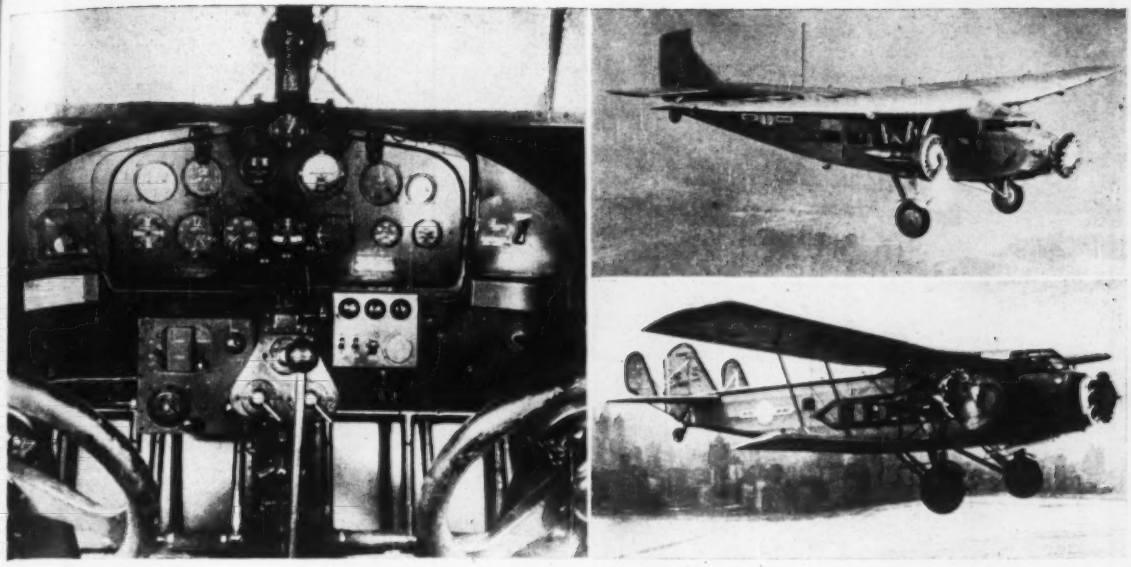
Fortunately, a number of pilots were willing and anxious to approach instrument flying from a positive standpoint. They learned that it was possible to fly the airplanes for long periods of time entirely by instruments. The mental gymnastics were found to not be so involved as the task became more routine.

Further improvements in instruments greatly simplified the task. The development of the gyroscopic artificial horizon and gyroscopic direction indicator were major steps in making the job easier for the pilot and in improving accuracy. The sensitive altimeter, which would respond to changes





1927.—Early commercial airline instruments like these were installed in single-engined Boeing 40-B-4's of the type which United Air Lines' predecessor, Boeing Air Transport, used in operations between San Francisco and Chicago in 1927. Note the extreme simplicity of this instrument panel as compared with that of United's latest commercial transports, the Douglas DC-6 and Boeing Stratocruiser.



1928-29.—Instruments multiplied as United's predecessor companies began flying tri-motored airplanes such as the Ford and Boeing 80-A. Three engines obviously required more instruments than one, but flight instruments actually had not advanced much by this time.

in altitude of as little as five to ten feet, the sensitive climb indicator and more accurate tachometers, manifold pressure gages and other power plant instrumentation, greatly increased the security of flight.

To visually illustrate some of this advancement, we have prepared a number of slides which will show how the number of instruments have increased in transport airplanes during the past twenty-five years.

[ED. NOTE.—At this point the reader should examine the illustrations one by one: they are arranged in chronological order.]

I think the requirements for aircraft instruments have been somewhat unique. We have demanded reliability, sensitivity and accuracy, but at the same time have required that the units must be extremely light in weight, small in dimension and have an ability to withstand extreme variations in temperature, pressure, accelerations, etc. We have also required that they be rugged and capable of being serviced and repaired in airline shops. We have asked that the indications be readily and easily readable under both day and night conditions and that there be sufficient differentiation in appearance in order to avoid confusion as to the function being observed.

There was a period in the development of aircraft instruments when there was a reluctance on the part of most instrument manufacturers to appreciate the importance of these requirements, probably because in other industrial applications there had never previously been the same stringent limitations upon weight and space and the same necessity for accuracy, reliability and ruggedness.

Looking back now at the development which has ensued, I think that

1933.—In the Boeing 247, introduced into service by United Airlines in 1933, the instrument board began to take on a modern appearance. Note the thoughtful arrangement of the panel with engine instruments to right and left and flight instruments centered; also the over-all clean design. In the 247, as in subsequent airliners, instruments multiplied as engineers provided different types with multiple functions in order to have checks and double checks in the interests of safety.

we all marvel at the progress which has been achieved. Extremely high precision movements and mechanisms have been developed. Accurate indications are obtained quite remote from the point of measurement.

Pilots will now often fly for a considerable length of time without looking out of the cockpit at their engines. This is not an indication of carelessness; it is a case of concentration and dependence upon the instrument equipment from which they will receive any warning of difficulty long before it will be externally visible. Flight control instruments are now equally dependable and enjoy an equivalent confi nce by pilots. You are all familiar wit the fact that modern aircraft fly i definitely in clouds, even under t rbulent conditions, without the pilots ever seeing anything except the instru ment board. Yet the course, the altitud and the attitude of the airplane ar all under precise control. With the a sistance of the radio communication system the pilots know exactly where they are and are able to report accur ately on the progress of the flight at all t mes.

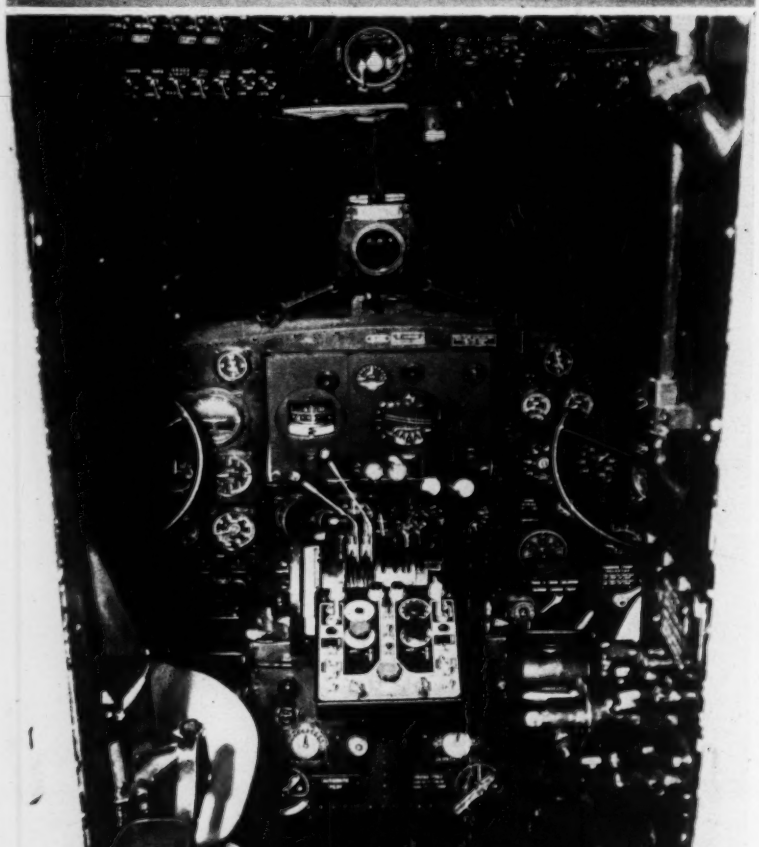
So far in this discussion nothing has been said about recording instruments. We have not made use of many recording instruments in our aircraft except for flight test work. It is my prediction that recording instruments will find greater application in aircraft as time goes on. I am sure that efficiency can be improved greatly by having proper records of every flight. At present we depend primarily upon the logs maintained by the flight crews. These are fairly adequate, but are time-consuming and never report complete simultaneous recording of all functions.

Size, weight and cost have been principal deterrents to the more general use of recording instruments. It is my hope that the instrument industry will see fit to put greater emphasis upon the reduction in size and weight and expense of recording equipment so that it can be more generally available for aircraft usage. Space and weight are at a premium in a modern airplane.

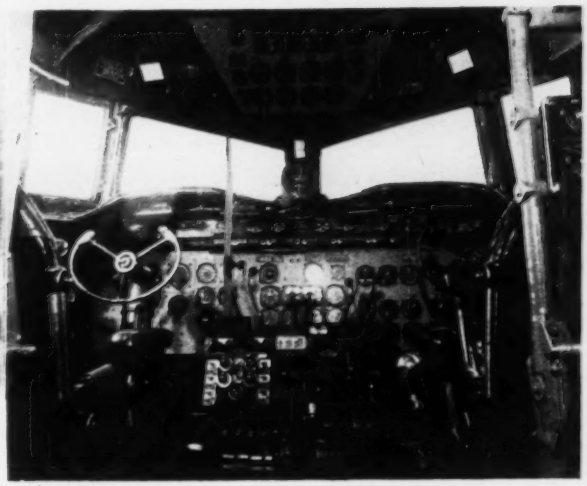
Full automatic flight has been achieved in tests and is surely an eventual goal. Even now the automatic pilots perform a major amount of routine control of the airplane. The same basic sensing elements which are employed for direct instrument indications are used in the automatic control devices. Gradually but surely, the burden upon the human element is being lessened, and precision and safety are being improved.

Many of the refinements in instrument design which were first required for aircraft are now being utilized in many other applications. Aircraft industry engineers are gratified to learn that these design improvements can be used elsewhere than in an airplane. We feel that thereby we have made a contribution to the measurement and control problems of every industry, thereby promoting the achievement of better economies and efficiencies.

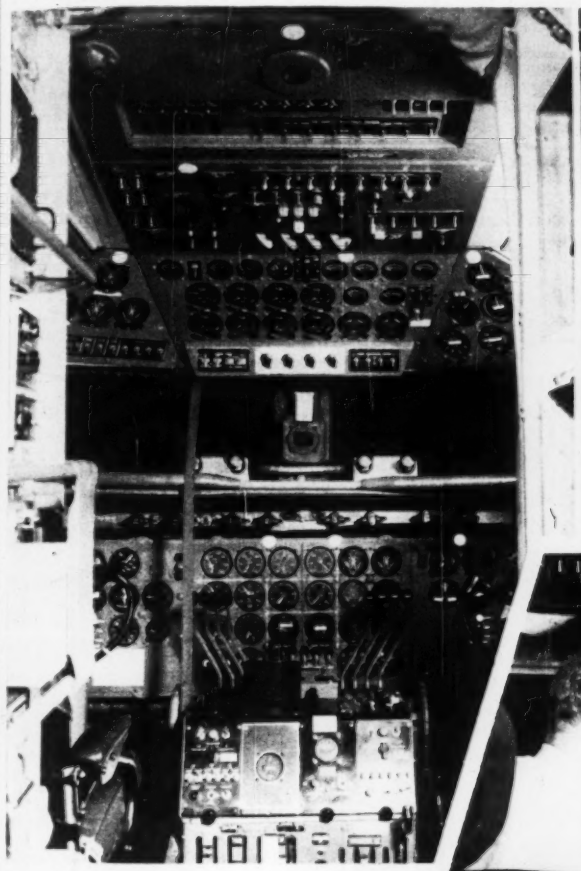
The air transport industry today owes much to the ingenuity and the achievements of the instrument manufacturers. No modern airplane could be flown without proper instrumentation. At the same time, we would not have you believe that the ultimate has been reached. In many respects air transportation is only in its infancy. To achieve the broader horizons of higher speed, greater comfort and safety, and greater economies and efficiencies, we will be requiring still more precise and effective mechanisms. We shall look to the instrument industry for continued assistance and we believe the eventual benefits will be mutual.

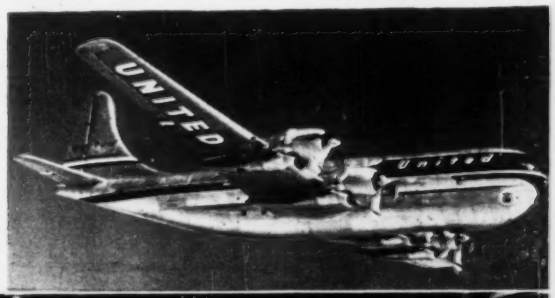


1936.—The Douglas DC-3 instrument panel looked, to the layman, to be complicated when this plane was introduced in 1936. Actually, increasing thought had been given to the utilitarian location of instruments and new devices had been added such as the automatic pilot shown in upper center of this photo and the radio control panel lower center.



1946.—The Douglas DC-4 presented increasing complexity of instruments, having four engines as against the DC-3's two, but again careful thought toward their location was displayed.





1949.—The Douglas DC-6 (above) and the Boeing Stratocruiser (right) mark the latest in airline instrumentation. Both of these newest types of airliner are pressurized; both are designed to fly at 15,000 or even 20,000 feet at 300 mph. or more. As against the four or five instruments carried in the Boeing 40, United's Mainliner 300 (DC-6) mounts 83 individual instruments. Capt. R. L. "Rube" Wagner (holding mike) "instructs" United's Number One Pilot Capt. Harry Huking. Each has had well over 20,000 hours of flying.

Design *of a* Chemical Process *for* Instrumentation

By C. W. HILLS, Shawinigan Chemicals Ltd., Shawinigan Falls, Quebec

SUCCESSFUL instrumentation of any chemical process depends on many factors, but primarily the use of automatic-control mechanisms requires the incorporation of certain characteristics into the design of chemical processes to permit the application of modern methods. The designer must be constantly aware of the factors that contribute to the satisfactory operation of process instrumentation and provide these conditions by the proper design and selection of equipment.

Let us assume that we have a so-called "typical chemical process" requiring equipment to provide for an exothermic catalytic reaction, between an organic vapor and a gas, to give a condensable product and a spent cyclic gas stream.

The Process

The fundamental units of the process may be listed as follows:

(a) Catalytic reactor
(b) Circulating system for the gas
(c) Vaporizer for the organic liquid
(d) Product condenser

The operating conditions of the process are such that the reaction temperature must be in the neighborhood of 200 C., and the pressure approximately 10 psig.

The ratio of gas to organic vapor is a critical factor and must be maintained within narrow limits.

Furthermore, the reaction rate is readily susceptible to slight changes in temperature and moderately influenced by variations in pressure.

To maintain these conditions the following auxiliary process equipment must be added:

(e) Cycle gas preheater
(f) Heat-removal system for catalytic reactor

This completed system can be illustrated by a simplified flow sheet. (Fig. 1). The problem of the design engineer is to provide these component parts of the system so that they accomplish the desired results, with a minimum of operating labor and supervision. His chief aim is to make the system entirely automatic and safe.

Major Process Controls

Since the major control problems will be connected with the catalytic reactor, cycle gas preheater, and vaporizer, these items will be considered in the order of their relative importance

Catalytic Reactor

Preliminary investigations have indicated that the most satisfactory type of reactor is a tubular type with catalyst in the tubes and a heat removing medium in the shell.

If the dimensions of the reactor are suitable for high shell pressures, the heat of reaction may be removed by the evaporation of water. If the reactor is of sufficient size to make the use of high shell pressure impractical, some other method of heat removal must be employed.

In this "typical chemical process" we have chosen a reactor that must use a low pressure system to remove the heat of reaction. On the basis of instrument application, two systems can be adapted with equal satisfaction. These systems consist of either the circulation of a suitable oil, or the vaporization of an organic liquid with a satisfactory boiling range. With minor alterations the same control system can be utilized for either method. Therefore let us assume that the latter method of liquid vaporization has been selected.

In this case the shell of the reactor is maintained at a constant temperature by the boiling point of the organic liquid at the operating pressure. Heat is removed by the vaporization of this liquid. If a closed system is desired, the vaporized liquid must be condensed and returned to the reactor shell under conditions that maintain the desired operating pressure. The rate of heat removal is ultimately regulated to maintain a fixed temperature of the exit cycle gas from the reactor and thereby control the rate of reaction at the desired value.

A control system to accomplish these results is indicated in Fig. 2 and can be briefly described as follows:

The output from a temperature controller, actuated by the temperature of the outlet gas from the reactor, sets the control point of a level controller, maintaining the height of the condensing medium in the shell of the reactor coolant condenser, and thereby controlling the rate of heat removal.

In order to provide for wide fluctuations in reaction rate, an additional refinement has been added to increase the effectiveness of the control char-

* Presented at ISA Regional Meeting, Toronto, Canada, May 12, 1949.

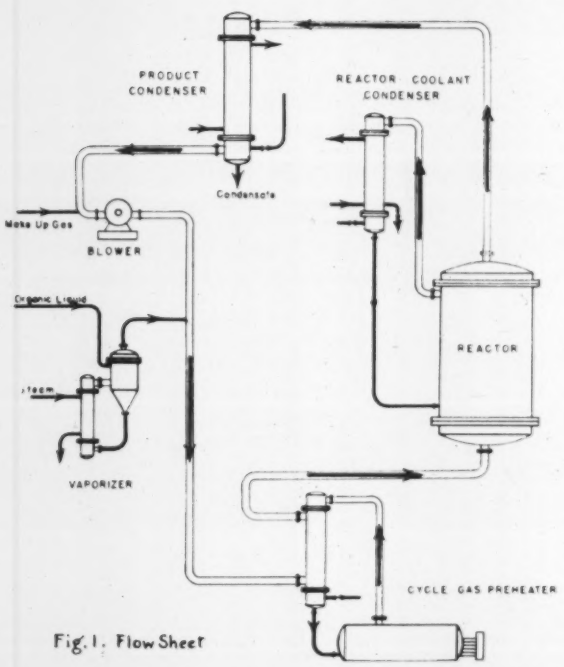


Fig. 1. Flow Sheet

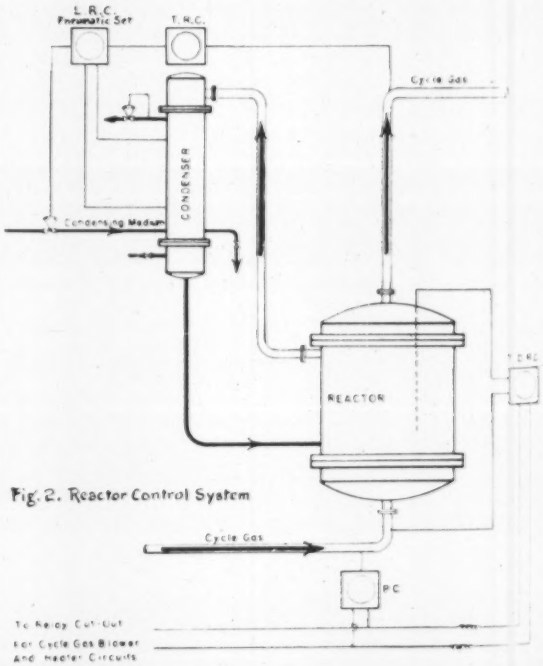


Fig. 2. Reactor Control System

acteristics of the level instrument. This auxiliary system consists of an adjustable back-pressure regulator on the blow-off for the condensing medium on the shell side of the reactor coolant condenser.

The effect of this pressure regulator is to vary the available temperature difference across the tubes of the condenser and permit the use of a level falling within a satisfactory operating range of the level controller, regardless of the desired rate of heat removal.

With some sacrifice in control characteristics, other combinations of instruments may be used that would eliminate one or possibly two of the units involved in this control system. However, no attempt will be made to elaborate on these alternatives and we will proceed to the next item mentioned under major process controls.

Cycle Gas Preheater

Depending on the process, its location, and the prevailing facilities, various methods of preheating the cycle gas, prior to its entrance into the reactor, are normally available.

The operating requirements of this "typical chemical process" are most adequately met by a system very similar to that employed on the reactor for heat removal.

The reactor is replaced by a suitable boiler and the condenser becomes a heat exchanger imparting heat to the cycle gas on the shell side. Maintenance of a fixed cycle gas temperature, by regulating the heat input to the boiler, is the main control problem. This heat input may be accomplished by an oil or gas burner or by electrical energy.

Oil or gas burners offer a simple means of introducing a controlled heat input regulated to comply with the process demand. However, in many installations, the difficulty encountered in utilizing this method of control in hazardous locations may offset the normal control advantages. Therefore let us consider a case where an electrical explosion-proof installation is preferable.

Under these conditions, a variable heat input must be supplied depending on the process demand. If variations in cycle gas temperature were not critical, this could be easily done by manually introducing different banks of electrical heaters. However, the requirements of this "typical chemical process" originally state that the reaction rate is readily susceptible to slight changes in temperature, therefore a proportional variation of heat input is essential. Instrumentation to accomplish this control of electrical heat input is shown diagrammatically in Fig. 3 and may be described as follows:

A potentiometric type instrument, actuated by the temperature of a thermocouple located in the outlet gas stream from the heat exchanger of the cycle gas preheater, positions a slidewire contact, or similar mechanism, regulating a direct-current supply to the grid of a thyratron tube circuit. The thyratron circuit, in turn, regulates the direct current on the field of a saturable-core reactor installation controlling the alternating current to the electric heating mechanism.

This type of control system may be obtained with an adjustable proportional band and reset response, thereby providing facilities for maintaining a constant temperature for any normal process lag and variation in process load.

Vaporizer

The next major process control problem concerns the regulation of the rate of vaporization of the organic liquid into the cycle gas stream. One of the simplest and most satisfactory methods of introducing this vaporized liquid into the gas stream is by the use of a standard calandria type installation, using steam as the heating medium.

This type of vaporizer is indicated in Fig. 4 and the control system to maintain a constant ratio between the vapor and cycle gas flow utilizes a flow-ratio controller actuated by flow-measuring elements in both the vapor and gas streams.

The size of these flow elements may be chosen to provide the average operating conditions for an instrument ratio setting of 1-to-1 and then a change in the instrument control point will usually provide the required operating latitude for all rates of production. Several control arrangements are possible for the flow-ratio controller but the one illustrated uses the calandria steam as the manipulated variable to alter the rate of vapor flow which is the controlled variable.

Additional control instruments can be utilized to maintain the level in the vaporizer and provide for a controlled rate of residue withdrawal from the base of the calandria or separator.

Safety Controls

Apart from the normal precautions of installing safety heads and relief valves on process equipment, provisions for safe operation of a chemical process usuallly depend on some type of instrumentation.

In this particular process a high pressure at the inlet to the reactor trips a mercury switch operating relays that give an initial alarm and eventually open the blower motor circuit if the inlet pressure to the reactor exceeds the value permissible for a controllable reaction rate.

Another limit control on the reaction

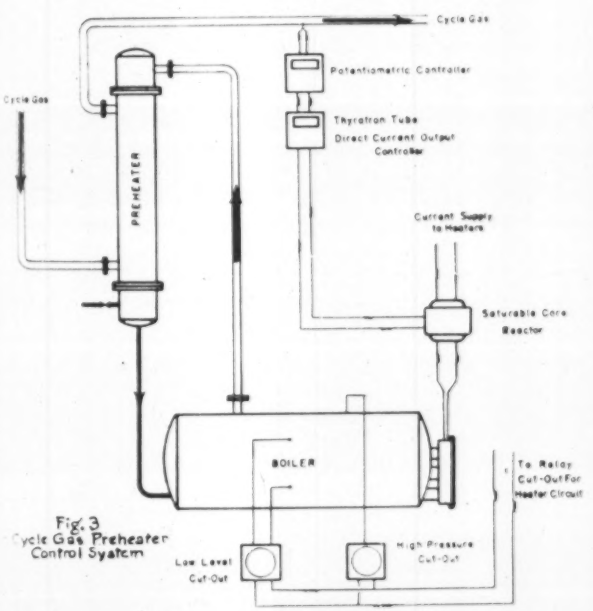


Fig. 3
Cycle Gas Preheater
Control System

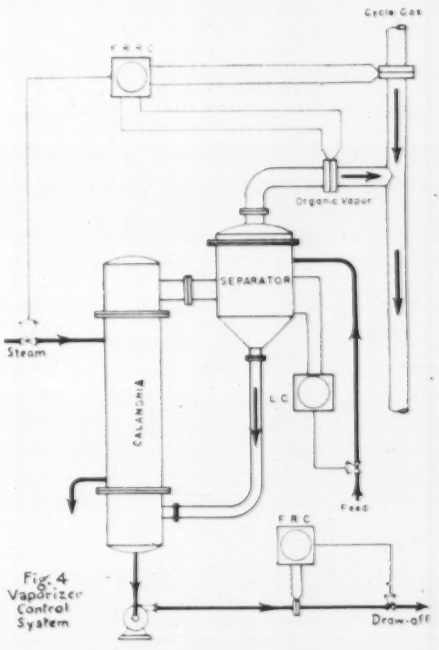


Fig. 4
Vaporizer
Control
System

rate is a pyrometric instrument measuring the temperature difference between the catalyst "hot-spot" and the inlet gas stream. In cases where this temperature difference varies as the rate of reaction, limit points can be selected to progressively give an alarm and open circuits on the preheater elements and cycle gas blower, before a "run-away" reaction develops.

Heat input into the preheater may be cut out by instruments that are actuated by a low boiler level or a high boiler pressure.

Instrument Installation

Alarm signals may be conveniently used to signify that a cycle gas blower has stopped, make-up gas pressure is low, condenser water is too cold, or any other indication that will aid the operator to correct any situation that impairs or endangers the proper functioning of the process.

Now that the control instruments for this "typical chemical process" have been designated, provisions should be made for their satisfactory installation.

If the process is to be housed in a new building, the location of a central control room can be chosen and incorporated into the original lay-out of the plant. Let us suppose that this particular process is to be placed in an existing building. Furthermore, as is usually the case, the proposed installation does not provide a readily-accessible area for a central control room.

Under these conditions the most satisfactory installation will probably involve the use of transmitting and receiving instruments with the latter located in the central control area.

In this way pneumatic or electric transmission lines can be readily run to a remote location and the receiving instrument can be chosen to act as an indicator, recorder, or controller with any or all of the standard instrument characteristics.

The use of transmitters and receivers not only simplifies the problems of instrumentation but in many cases the process piping can be kept to a minimum when the long runs to a central control room are not necessary.

After the pneumatic instruments have been properly installed, one final provision must be made to contribute to their satisfactory operation. Clean dry air at a suitable pressure is essential. This air may be supplied by individual compressor units, but in general a central compressor station is more dependable. Elaborate precautions against air supply failure justify their incorporation into any supply system upon which the operation of pneumatic control instruments depends. The result of a poor source of instrument air is usually high instrument maintenance costs and poor process operation, which has, in some cases, led to erroneous conclusions concerning the benefits of modern instrumentation.

Instrumentation Problems *of the* Vibration Field Test Engineer

By NORMAN H. JASPER, Mechanical Engineer, David Taylor Model Basin, Navy Department, Washington, D. C.

THIS ARTICLE is written from the viewpoint of the field test engineer who deals with problems in vibration, dynamic strength and shock. The experience of the author has been almost exclusively limited to naval ships and equipment.

Instrumentation in itself is a highly specialized science, in which the applications to shock, vibration and strength problems play a limited part. The instruments and associated equipment are tools to the engineer who will use them in an attempt to obtain desired information, and just as a mechanic uses the proper tool for each job so the engineer must use instrumentation which will best fit the conditions with which he has to deal.

It is a weakness of specialization that specialists become engrossed in their particular problems and tend to lose the perspective so necessary for balanced design. Instrument designers are not immune to such an attitude. We must remember that the purpose of instrumentation is to provide a means of obtaining information and that the detail and accuracy of this information must be consistent with the scope of the investigation and with the size of the pocketbook.

Factors which must be considered in any test are (a) service facilities available at the test site, (b) time available for test preparations, (c) control over test conditions, (d) available test personnel, and (e) the availability of funds. These factors are present, to some extent at least, in every problem. If the investigation is not limited to any appreciable extent by these considerations, then instrumentation may profitably be as extensive and refined as desired. In almost every case, however, some limitations exist and, for the great majority of field tests, all of these limiting factors must be taken into careful consideration.

It may be stated, in general, that tests conducted on shore establishments are more amenable to controlled conditions than those conducted aboard ship. The test engineer has a multitude of factors to take into account. Let us consider a shipboard test. The problem itself may not be specifically defined at the time that the engineer leaves his base. The test may require certain weather conditions. The program may have to be fitted into the operating schedule of the vessel. The ship's officers may have to be convinced of the desirability of certain tests; cooperation must be obtained from the personnel concerned and a number of minor details must be attended to.

Having decided what information is to be obtained and how it is to be obtained, the engineer must choose the proper instrumentation. If these various decisions have to be made aboard ship it is necessary that the instruments taken for the test be flexible in application and simple in operation. The instruments should be dependable in operation and should maintain their calibration over reasonably long periods of time.

It is important to remember that the opportunity for obtaining the required data, once it has passed, may not recur. In this connection I might point out the desirability of using direct-recording instruments which permit visual inspection of the records as they are obtained. Using such a recorder will spare one the embarrassing experience of developing a roll of records and obtaining a complete blank. At the same time such a method will permit a rapid rough evaluation of the data, which may be necessary in order to determine any additional runs to be made. It is not advisable, in many field tests, to install instrumentation which requires specialists for installation or operation, or which necessitates special arrangements for power supply or for processing.

I should like to stress the necessity for designing sufficient ruggedness into the equipment to enable it to withstand the handling it will receive in shipment or aboard ship. It is not ordinarily feasible to send a man along with a shipment of equipment; the phrases "delicate instrument," etc., do not command much attention. Delicate laboratory instruments are not suitable for field tests. I wish to make it clear at this point that precision instruments are desirable, but if they are to be used in the field they must be designed for field conditions.

On occasion it is necessary to install instruments in locations remote from

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.

inaccessible to ordinary power supplies. In such cases it is advantageous to have instruments which are independent of power supplies, perhaps mechanically-actuated or battery-operated.

One might suppose that it would be desirable to obtain as much data as possible in a given test. This is not necessarily true, as one might be overwhelmed by the mass of data obtained and valuable time would probably be lost in extracting the data pertinent to the problem. In general it would be better to obtain the data necessary for the solution of the problem and be sure of their reliability. This might be the time to note the desirability of developing instruments which will give an index of the characteristics that we wish to determine. For example, we may be interested in the bending strains of the hull in a seaway. If one knew the number of times certain strain amplitudes were exceeded that might be considered as an index of the stressing of the ship even though the complete strain-time history of the hull girder is not known. Or if we knew the number of times the ends of the ship were subjected to given peak values of acceleration, we would have another such index. One might derive an index of the effective value of mechanical shock applied to a structure; for example we might let this index be equal to the work imparted to the structure in a given fraction of the natural period of the structure, that is, the index would have the dimensions of power. It is not always necessary or convenient to have the entire time history of the motion of a structure if we are interested only in the effects of such motions or in statistical analyses.

Absolute accuracy of vibration and shock measurements is not usually of paramount importance since the test conditions themselves are not accurately controllable. I would say that, on shipboard tests, measurements of amplitude, velocity and accelerations are acceptable if they are accurate within 10 per cent of their true value. Even maintenance of such accuracy is difficult if instruments do not maintain their calibration, when instruments are exposed to salty moisture-laden atmospheres, to variations in temperature, to oil spray and the like.

Although we are trying to measure vibration and shock data, we occasionally find that the recording and amplifying equipment will not operate satisfactorily when subjected to such vibration and shock. This shortcoming necessitates special design of vibration-isolating or of shock mountings. Such precautions are trying, and, I believe, should be unnecessary. The equipment should be designed to operate properly when subjected to field conditions. Data supplied by instrument manufacturers should include a statement of the range of frequencies and corresponding acceleration over which the equipment will operate properly.

Let us now consider the frequency response characteristics desirable for shipboard measurements. The great majority of difficulties due to vibration, and perhaps shock also, are caused by resonance between the frequency of an exciting force and the natural frequency of some particular structure. The exciting forces aboard ship are of propeller-blade frequency or are due to unbalance of rotating machinery. The top frequencies we are interested in are determined by the exciting frequencies encounterd aboard ship and by the natural frequencies of shipboard structures, whichever is lower.

Shipboard tests show that the natural frequencies of structures are below 100 cps. in about 95 percent of the items investigated. The frequencies of the exciting forces are below about 130 cps., considering that the highest shipboard turbine rpm. is about 7500 rpm. However, turbines are generally well balanced and therefore will not affect the hull structure or structures located away from the immediate vicinity of the turbine. The most widely felt exciting force is of propeller-shaft or propeller-blade frequency and this frequency is below 30 cps. for displacement type of vessels.

Frequencies of practical interest are therefore limited to a maximum of 100 cps. and even in this range the frequency band up to 30 cps. predominates because it is this lower range that most objectionable resonances occur.

Accelerometers used on shipboard vibration tests should have some kind of filter arrangement in order to remove undesirable higher frequency response which tends to confuse the record.

Displacement pick-ups for shipboard use should have a low frequency response; if possible, be reasonably flat from 1 cps. up. The lower limit requirement makes for a heavy instrument. For this reason it is often more practicable to use a suitable accelerometer for measuring these lower frequencies. The dry friction at bearings, recording pens, etc. should be kept to a minimum. This is very important, since at low frequencies and low amplitudes large deviations from the theoretical response may result from dissipation of the available energy in dry friction. Flexure-plate hinges are to be preferred over pivot bearings. The foregoing remarks also apply to velocity pick-ups; this type of pick-up usually has a higher natural frequency than do the available low-frequency vibrographs.

I believe that some of the most reliable vibration measuring instruments today are still the Geiger type and the pallograph type vibrographs. Of the more recent good instruments I should like to mention the Consolidated Type 4-102 velocity pick-up which is especially applicable when used with an integrator and with the direct-inking Brush Magnetic Oscillograph. The Askania vibrograph is a convenient recording hand instrument. The General Radio crystal accelerometer used with double integration together with the Brush direct-inking recorder is a good combination of limited use; however the stability of the over-all calibration needs refinement.

It is hoped that this article has been able to impress on the reader the problems that the man in the field has to deal with and perhaps this will help the reader when designing or acquiring instruments for field use.

Instrumentation Course in Connecticut

HARTFORD, Conn.—The first course in industrial instrumentation to be offered by a New England school other than a college or university has been authorized at the CRL School of Electronics, Hartford. Authorized by the Connecticut State Board of Education the course is being patterned after those offered at MIT, Massachusetts State College and Rhode Island State. The objective is to teach electronics students at CRL School how to use and maintain the devices on which industry depends for accuracy of measurement in products, humidity control and other factors. Instruments being studied include those which operate mechanically, pneumatically, electrically or electronically. John Alden Settle, formerly of the research and development division of Monsanto Chemical Co., Springfield, Mass., an M. E. graduate of St. Louis University, is teaching the new course.

Some Considerations *in the* Application *of* Instruments *to the* PULP *and* PAPER INDUSTRY

By R. M. BROWN, Instrumentation Engineer, Stadler, Hurter & Co., Montreal, Quebec.

PULP for paper or for chemical purposes may be made from any material which is high in cellulose fibre content and which is economical to use. In Canada it is wood. We have been said to have the "spruce psychology" because spruce trees are plentiful and contain a high percentage of cellulose fibres; and because means have been developed for pulping the wood at not too high a cost. In India, bamboo is used as the raw material; in Australia and South America the eucalyptus tree; and in the Southern United States the southern pine. Pulp may also be made from rags, straw, sugar cane and many other materials.

To understand the problem facing the instrumentation engineer, it is first necessary to know something of the process .Although not as complex as some of the oil and chemical processes, it nevertheless has its own peculiar problems. As a fellow engineer put it, it would be ideal if it were possible to cut down a tree and, without the bother of trimming or barking it, feed it into a huge machine that would engorge it, birds' nests and all, digest it and spew forth, through a multitude of outlets, numerous products and by-products. While such a dream in a modified form may come true in years to come, the manufacture of pulp and paper will remain, for an indefinite period, a multiple-operation process. Let us review the various operations briefly as they concern the manufacture of wood pulp in this country.

Wood (and this applies to practically all vegetable materials used as sources of pulp) consists of cellulose fibres cemented together by an amorphous compound called lignin of which chemists know little; it also contains sugars, some fats and various gums. The object in the pulping process is to obtain the cellulose fibres. These fibres give strength to paper made from such pulp and these fibres, too, are the source of cellulose in pulp used for chemical purposes. There are two common methods to obtain these fibres: (1) the mechanical process in which the fibres are torn free mechanically and (2) the chemical process in which the fibres are separated from the lignin by dissolving the lignin.

Fig. 1 outlines the first method, the mechanical pulping process in which the fibres are separated from one another by the action of a huge grindstone. The fibres thus produced contain not only the cellulose fibres, but all the lignins too. Such pulp is commonly called groundwood. Its greatest use is in the manufacture of newsprint which contains approximately 85 percent groundwood.

The principal stages in the process are shown in Fig. 1. Logs from wood storage are fed to huge grinders and pressure exerted on them to force them against the revolving stone. The stone must be cooled by means of a water spray and the rate of pulp production varies with the temperature: the

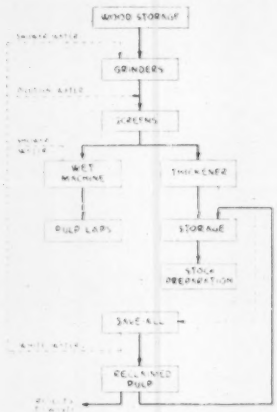


Fig. 1. Flow diagram of mechanical pulping process.

higher the temperature, within limits, the greater the production. Other water showers dilute the pulp, which then goes to coarse screens and fine screens, by which the unground fibres, slivers, etc., are removed. The accepted stock may go to a wet machine in which the stock passes over a rotating cylindrical screen and on which a sheet is formed, after which the sheet passes through an oversize wringer or press which squeezes out most of the water. The pulp sheet is cut off in lengths; folded or lapped, then stored or shipped. If the pulp is to be used in the same mill it goes to a thickener (again a rotating cylindrical screen) which removes only part of the water. The thickened stock then goes to one or more storage chests and from these to various refining and mixing processes.

In the chemical process, the fibres of cellulose are separated from the lignins by cooking the wood at high temperatures in either strong acid or alkali, depending on the particuar method employed. Fig. 2 shows, as before, the principal steps in the process. In this process, the wood is first reduced to chips about three-quarters of an inch in length and fed to huge pressure vessels called digesters. The cooking liquor is then pumped in and, when the proper quantities of chips and liquor have been placed in them, they are then sealed. The liquor is then heated either by injecting steam directly into the liquor in the digester, or, if the liquor is circulated, into the circulating line. If the digester is equipped with an external heater, the liquor is heated by circulating it through this external heat exchanger, with liquor on one side, steam on the

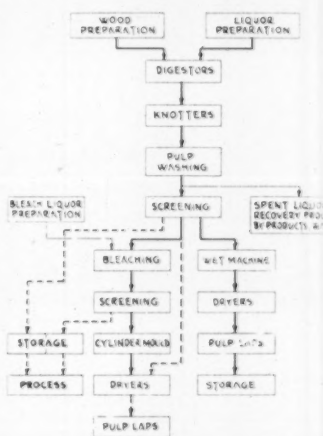


Fig. 2. Flow diagram of chemical pulping process.

other. The temperature of the mass is brought up according to a time schedule and the pressure of the digester is also maintained at the correct value corresponding to the temperature by automatically-controlled pressure-relief valves. After the mass of liquor and chips has been cooked the proper length of time the pulp is "blown" to blow pits or tanks. It may be washed by diffusion right in these same blow pits, after which it is screened, or it may be sent to a coarse screen called a knotter to remove the uncooked chips, pieces of digester lining which may have spalled, knots, etc. It is then washed to remove the cooking liquor and sent to the fine screens. As in the case of mechanical pulp, it may go to wet machines and be stored as pulp laps or shipped. It may also go through a bleaching process and be dried and sold as bleached pulp or it may be used without bleaching in combination with mechanical pulp —as in the manufacture of newsprint. The spent cooking liquor which has been washed out of the pulp may go to a recovery process which recovers a large part of the chemicals for re-use, as in the case of the alkaline process

* Presented before the New Jersey Section, ISA, March 1, 1949; and at the ISA Regional Meeting, Toronto, Canada, May 12, 1949.

nd a new acid process, or it may go to by-products plant if from the calcium bisulphite process. In the majority of cases, the liquor from the last-named process goes down the sewer to be lost forever.

The foregoing descriptions of the processes have been highly condensed; the processes are much more detailed and complex than the outlines indicate.

It will be seen that there are temperatures and pressures to be controlled, flows of chemicals to be metered and controlled, levels in storage tanks to be indicated and recorded, pH values to be maintained—in short, that there is a big job of instrumentation to be done.

An engineer applying instruments to a process works from a flow sheet of the process. On this drawing or drawings is shown the equipment used, the flow of stock, chemicals, water and steam. Quantities, consistencies, pressures, temperatures and pH values are

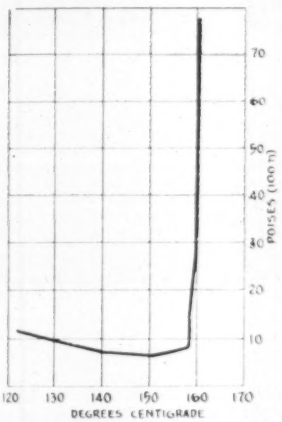


Fig. 3. Temperature-viscosity curve for sulphur. (Data from International Critical Tables.)

shown. Pipe sizes may be given. Before any job gets very far along, certain standards are established which cover permissible velocities, steam and water pressures, materials of construction, etc. The engineer starts off with a lot of information before him which simplifies his job considerably. It is now up to him to apply the control instruments which will make the process behave as it should, to provide recorders and indicators which will guide the operators and furnish information for cost accounting and other purposes. As in every industry, the end product is the main consideration—enough must be produced, meeting the standards of quality set to show a profit on the capital invested. Instrumentation, therefore, is not the end in itself, but only a means to an end.

It is not the purpose of this article to discuss instrument applications in detail.* Rather it is intended to discuss the subject along broader lines; to point out certain factors which must receive consideration.

Since liquor preparation is one of the first steps in the process, that makes a good starting point. Whatever the nature of the cooking liquor, there is a chemical process to deal with, and the instrumentation is applied as it is to any other chemical process. In the sulphite process the acid is prepared by first obtaining SO_2 from burning sulphur, then having this gas react with limestone in the presence of water, or with milk of lime, to form calcium bisulphate acid. Usually the sulphur is melted before being fed to the burner and its temperature must be controlled carefully. The viscosity of sulphur decreases as its temperature increases, up to a certain point, and then it increases. If the temperature varies either way too much, the flow of sulphur is retarded. This temperature-viscosity relationship is shown in Fig.

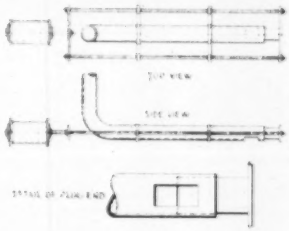


Fig. 4. One type of molten sulphur valve.

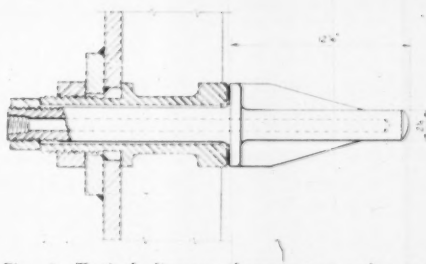


Fig. 5. Typical digester thermometer socket and sleeve.

3. The usual operating temperature is about 280 F.

In the suphur burner itself, the level must be maintained constant in order to have a uniform area of sulphur exposed at all times and so keep the production of sulphur vapor constant. This applies to the rotary type burner used in most mills. In some mills, the sulphur burner is of the spray type in which there is no pool of sulphur maintained. In the former, the level is measured by means of a bubble pipe level recorder controller, which operates a valve in the molten sulphur line. It would appear logical to use a controller with a wide proportional band to maintain a constant level, yet to do so may result in the valve freezing in one position merely because it doesn't move enough. It is better to use a narrow proportional band and allow the controller to hunt a little. The continual movement of the plug effectively prevents any freeze-up. Still another method of overcoming the trouble is in the use of special valves. One such valve is illustrated in Fig. 4. This valve is mounted in the combustion chamber and the temperature is high enough to prevent solidification of sulphur in the valve.

The pH of the acid produced in the acid plant is very low, from 0.2 to 3.0. It is highly corrosive and consideration must be given to the protection of all instruments used either in its production or its use. Type 316 stainless steel has been found to resist corrosion remarkably well and all the temperature bulb sockets, gage elements, dry type manometers and differential pressure transmitters are usually specified to be of this material. On the two latter types of instruments, that is, the dry type manometers and the differential pressure transmitters, it is common practice to use water purges for additional protection, although these may be of the intermittent type. Water used for purge purposes must be carefully filtered to ensure absence of scale or dirt, otherwise trouble may occur.

In the sulphate process, using liquor composed of sodium sulphate and various other sodium and sulphur compounds in solution, all of which are highly caustic, the corrosion problem is also present, though not as serious as in the sulphite process. Usually, mild steel will withstand corrosion for the caustic liquor although stainless is to be preferred. Above 250 F., stainless steel is affected and nickel should be used.

There is little need to dwell on the actual cooking process. As was mentioned, the mass of chips and liquor is cooked under presssure at high temperatures according to time schedules. Many good systems are available for both the sulphite and sulphate processes.

One problem which measuring temperatures within the digester poses is that of adequate mechanical protection to the temperature-sensitive elements. In the digesters, during the cooking period, there are terrific surges of the mass of pulp and any ordinary socket would be bent and broken in no time at all. To avoid this, the sockets used are made of rugged castings of stainless steel as shown in Fig. 5. These sockets are usually supplied by the mills.

After the pulp is cooked and blown into the blow pits or blow tanks, it is then diluted with weak liquor or water and a mixture of pulp fibres and water results, which is called *stock*. The nature of the stock, irrespective of the method used in producing it, is certainly one that requires the consideration of the engineer.

Stock, to repeat, consists of short fibres of cellulose, or fibres of cellulose and woody matter in water or some aqueous solution. Should these fibres settle out and dry, they form a solid mass which is sometimes extremely

* Details have been covered in a series of articles which appeared in *Pulp and Paper Magazine of Canada*, reprints of papers which were presented at a special course in instrumentation for engineers in the pulp and paper industry in May 1948.

difficult to remove. All equipment through which stock passes should present smooth surfaces to the stock

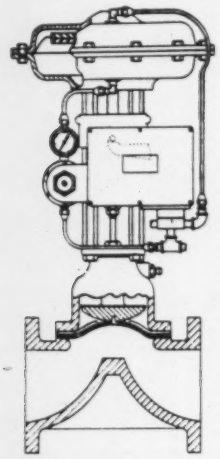


Fig. 6. Diaphragm-motor-operated Saunders Patent valve with positioner. (Adapted from Conoflow Corp. drawing.)

as flow control valves but a knowledge of their flow characteristics is essential for proper sizing.

Fig. 7 shows the flow characteristics of a 6-inch Saunders valve that is typical of all such valves. Note that the flow increases rapidly as the valve opening increases until about 50 or 60 percent opening is reached, after which further valve opening causes only a small increase in flow. For control purposes, that portion of the curve below 50 percent should be used. It is recommended that normal flow be taken at 35 to 40 percent of valve opening. Charts for sizing these valves are available and an example of valve sizing may be of value.

Fig. 8 shows a table of valve constants for various sizes of valve. Actually, these are valve coefficients, or the quantity of water which a valve will pass at the various degrees of opening with a constant pressure drop of one pound per square inch. To use these figures for other liquids and other pressure drops, a formula is used:

$$K = (Q \times \sqrt{\text{Sp.G.}}) / \sqrt{P},$$

in which K is a constant, Q is quantity in U.S. gallons per minute, and P is pressure drop.

Assume $Q = 1000$ U.S. gpm., P 5

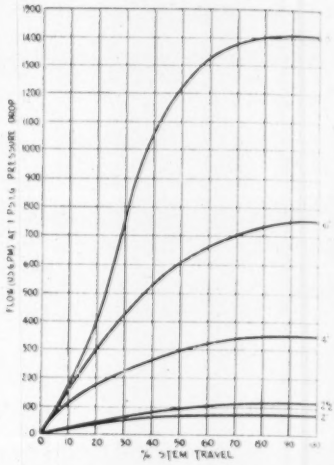


Fig. 7. Flow characteristics of Hills-McCanna Saunders valves. (Figs. 7, 8, and 9 from data supplied by Hills-McCanna Co.)

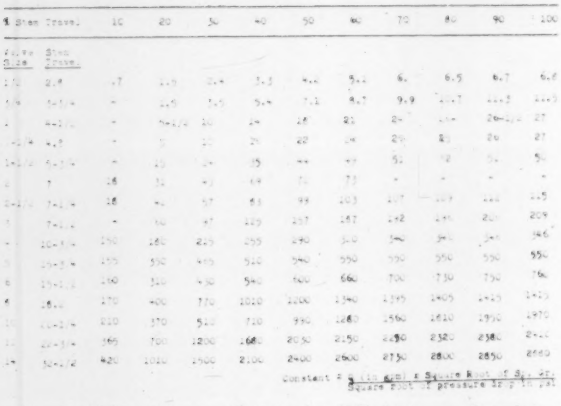


Fig. 8. Valve sizing coefficients for Hills-McCanna Saunders valves (cast iron).

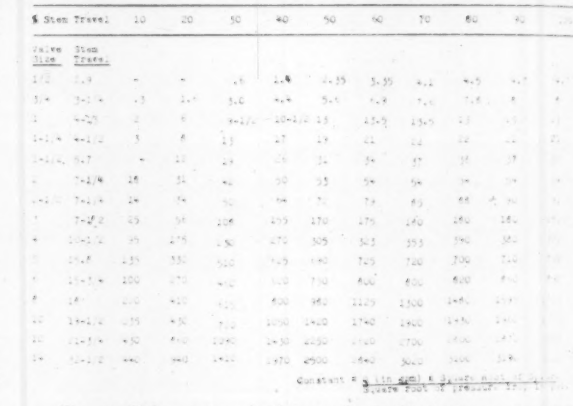


Fig. 9. Valve sizing coefficients for Hills-McCanna Saunders valves (rubber-lined).

and this applies to flow-measuring devices and control valves as well. It is for this reason that characterized plug type valves are not used on stock lines. Instead, such valves as the popular Saunders Patent Valve, the butterfly valve, the gate valve and various types of rotary plug valves are used. Since the last two are used primarily for on-off services, I think we may neglect them, but I should like to deal with both the Saunders Patent Valve and the butterfly valve.

An air-operated Saunders valve is illustrated in Fig. 6A. Note that it consists essentially of a streamlined casting against which a rubber diaphragm closes in the shut-off position. Such valves have been used in various industries on lines carrying slurries. Tight shut-off is possible even if fairly large size particles remain on the ridge of the valve body, by reason of the elastic nature of the rubber diaphragm. The valve bodies may be obtained in a wide range of materials and in addition may be rubber lined, lithcoted, glass-lined, etc. These valves are often used

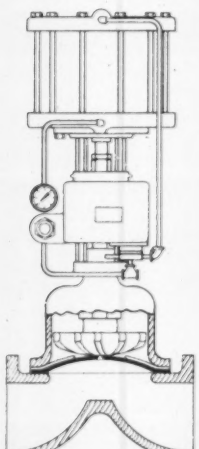


Fig. 10. Cylinder-operated Saunders valve with positioner. (Adapted from Conoflow Corp. drawing.)

psi. and the specific gravity as 1. By substitution, a value of 447 is derived for K. Since we wish to operate our valve at 35 percent opening, we run down the 35 percent column until we reach a value of K close to the one obtained. By referring to the valve size on the left-hand side, we see that a 6-inch valve is required.

It is obvious, of course, that diaphragm-motor tops cannot be used for valves over 4 inches in size, owing to the limited stem travel of the top works. For large valves, up to 12 inches, (the maximum size in Saunders valves) air-operated cylinders may be used. Valve positioners may be used in both types of operations and are a decided advantage, particularly if the line pressure is high. The force exerted on the diaphragm due to line presssure on large valves is considerable and air pressures up to 60 psig. may be required to ensure tight closing. Often these valves are loaded with air pressure of a definite value to hold them in a given position and a valve positioner will cause the valve to keep this

position regardless of variations in line pressure. Fig. 10 illustrates a cylinder-operated valve equipped with a positioner.

Saunders type valves are not commonly available in sizes larger than 12 inches and often valves larger than that are required. Butterfly valves are available in a wide range of sizes and may be used on stock or dilution water lines if certain considerations are fulfilled. It must be remembered that butterfly valves are limited in the pressure drop which may be used across them and usually this is a maximum of 50 psi. In most cases, the pressure drops are considerably less, in the order of a few pounds or a few feet. Sizing of butterfly valves presents certain difficulties, largely because of the fact that the manufacturers of these valves have not made a practice of issuing capacity charts, valve slide rules or other sizing information. Again, where capacity charts are available, the sizes obtained for equal flows and equal pressure drops in different makes do not agree. This seems odd, considering the essential similarity of the various makes of this

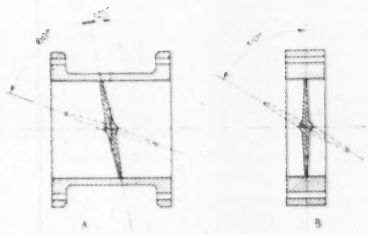


Fig. 11. Cross-sections of typical butterfly valves: (a) Vane closed at 12.5 degrees from vertical; (b) Vane closed at vertical position.

travel limited to this 60 degrees by means of limit adjusting screws.

It may be mentioned here that another make of butterfly valve has the vane set at 12½ degrees from the vertical at the fully-closed position and the angular movement of 60 degrees is measured from that position to give the final vane position as 72½ degrees from the vertical. It may be this difference in starting position that accounts for the difference obtained in sizing valves for equal flow characteristics.

of these valves should follow the methods used in sizing V-port valves. Given a maximum flow of 1000 gpm., for example, it would be usual practice to size the valve for some higher figure to avoid working the valve full-open at maximum flow rates and also to allow some excess capacity. An increase of 40 to 50 percent is not too great. In a V-port valve, at our flow of 1000 gpm., the valve should operate about 85 percent open. Similarly, in a butterfly valve, the vane would be at a position about 45-50 percent open, which would place the flow on a good portion of the flow characteristic curve. The flow curve for one make of butterfly valve is shown in Fig. 13.

Both Saunders and butterfly valves may be used on stock lines or white water lines. White water is the name given to the water drained off the stock and contains a very small percentage of fibres, from about 0.01 to 0.08 percent or even less if the filters and washers are of the latest type. Owing to this extremely low fibre content, V-port valves may be used on white water lines for the regulation of

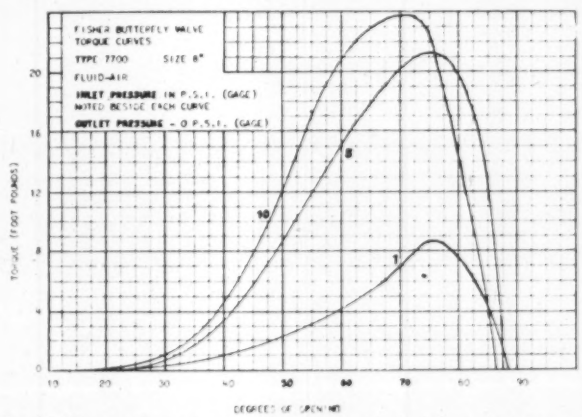


Fig. 12. Torque characteristics of Fisher butterfly valves. (Courtesy Fisher Governor Co.)

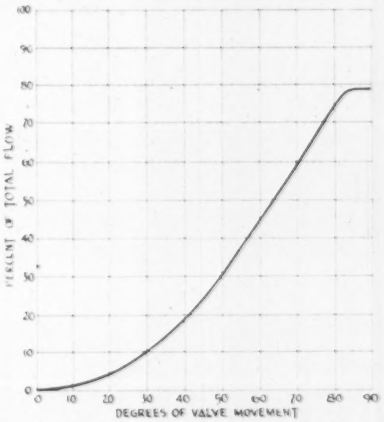


Fig. 13. Flow characteristics of butterfly valve. (From data by Continental Equipment Co.)

type of valve. It would appear necessary, and it is recommended, that valve sizes be checked by the supplier. However, certain limitations about butterfly valves should be known to an engineer using such valves. In Fig. 11 is shown a typical butterfly valve. The solid lines of the vane indicate the position of the vane in the closed position, the dotted lines the position of the vane in the position recommended for full opening when the valve is used for control purposes. The angle between closed and open positions is 60 degrees. The angular movement is restricted by reason of torque requirements.

Fig. 12 shows torque versus angularity. The torque, or power required to turn the vane, increases to a maximum at 72 to 75 degrees of opening, and then decreases rapidly. It has been found that control suffers if the valve is permitted to operate in a region of reversed torque, so, to avoid this, the maximum vane movement is limited to 60 degrees. Butterfly valves supplied for control purposes will have the vane

Since butterfly valves are said to have equal percentage flow characteristics, it would appear logical that the sizing

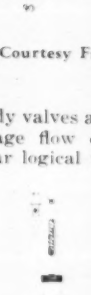


Fig. 14. Rotameter used on stock flows. (Courtesy Fischer & Porter Co.)

stock consistency which I will touch on later. V-port valves are also used on chemical lines although in some cases rubber-lined Saunders valves may be preferred. I will not discuss V-port valves as their characteristics are well known.

Although I have spoken of flow control in stock lines, I have not mentioned flow measurement. Here again, one must give consideration to the nature of the stock. The primary flow devices must not tend to cause pulp fibres to accumulate. For this reason, the concentric orifice plate cannot be used to meter this mixture of pulp and water or slush stock as it is often termed. They can be used to meter white water. On stock lines a segmental orifice may be used, *open at the bottom*. Venturi tubes may also be used, and are to be preferred by reason of their streamline construction. Water purges are used with these meters. In some cases, in which different types of stock are to be proportioned to one another, ratio control systems have been used with

rotameters as the primary device. These are illustrated in Fig. 14. Note that as far as possible pockets in which stock may accumulate have been eliminated.

Other types of primary measuring devices are the so-called stock meters, one of which is shown in Fig. 15. In these, as may be seen, the stock wheel is divided into pockets, each one delivering a certain quantity of stock. By adjusting the speed at which the wheel turns, the flow of stock may be regulated. These stock meters are used to control the rate of stock feed to bleach plants, pulp washers, proportioning systems, etc.

Another property of the stock which must be considered is its consistency. By air-dry consistency is meant the percentage by weight of air-dry fibre in a mixture of fibre and water. Three percent consistency refers to stock containing 3 pounds of air-dry fibre in 100 pounds of the mixture. Consistency varies widely from one part of the plant to another, or even in the same pipe line. Stock may be screened best at one consistency, for example; it goes to the washers at another consistency and to the drying machines at another. In the bleaching of pulp we have low-consistency stages and high-consistency stages, more commonly called low- and high-density stages. The terms "low" and "high" here are used in a relative sense, both being in the high-consistency range. In ordinary mill parlance, low-consistency stock is that below 1.5 percent and high-consistency that above 1.5 percent.

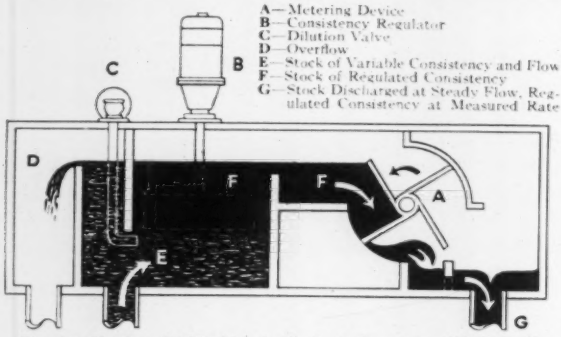


Fig. 15. Sherbrooke Machineries Ltd. stock meter with Dezurik consistency regulator.

The measurement and control of high-consistency stocks ranging from 1.5 to 6 percent is routine procedure in all mills and several good control systems are available for this purpose. They all work on essentially the same basic principles although details of design may differ. In measuring and controlling high consistency, advantage is taken of a relationship between friction loss and consistency, although this relationship is not linear. Fig. 16 shows a popular type of consistency controller illustrating the use of this relationship. The stock enters at the left-hand end, flows over a constant-head weir and along the flume to the outlet at the right-hand end. The difference in level between two fixed points is measured on a differential air-operated level recorder controller. As the consistency varies, the friction loss varies and the differential level also varies. The controller operates a valve in the dilution water line to add more or less water to the stock and return the level and consistency to the controlled valve.

Other systems of measuring and controlling high consistencies are used, but these are all fairly well known and need not be discussed.

The measurement and control of low consistencies is equally important and deserves consideration. In the range of consistencies below 1.5 percent, advantage cannot be taken of any consistency versus friction loss relationship. In fact, at certain low consistencies and flow rates, the friction loss may be less than that of clear water. Advantage is taken of another property, which may be called rate-of-drainage. If a sample of stock of a given consistency is placed on a screen, the water in the stock drains through, leaving the fibres as a mat on the screen. If the stock were of a higher consistency, the mat formed would be thicker and the water would drain off more slowly. It is apparent, then, that the rate of drainage varies with the fibre content or consistency. Fig. 17 illustrates how use is made of this relationship in practice. In this unit or sampling device, a sample of the stock, approximately 75 gpm. flows from a constant head box to the unit. In this unit a cylindrical screen rotates at a constant rate and, as it rotates, the water from the stock drains through it. If the consistency remains constant, the water drains through the screen at a constant rate and the level in the pond back of the screen remains constant. Should the consistency vary, the rate of drainage varies and the level in the pond varies. The variations in level represent changes in consistency and can be measured and used to operate a valve in the dilution water line or a valve in the stock line, depending on the particular control set-up used.

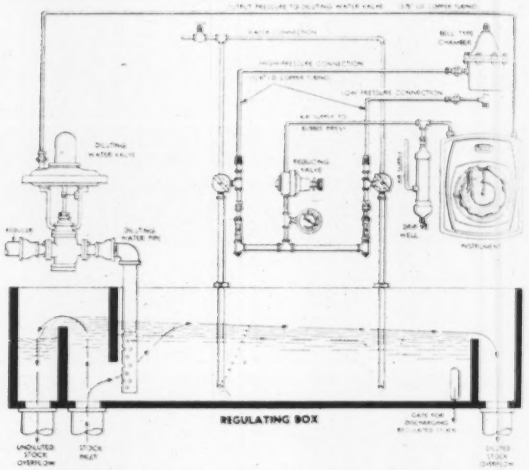


Fig. 16. Brammer consistency regulator. (Courtesy Paper & Industrial Appliances Co.)

These devices are in use in many mills and have proved very satisfactory if applied properly and used correctly.

One point should be noted when considering low-consistency control, and that is that the freeness of the stock should be relatively constant. Freeness of stock is a property of stock almost as much as specific gravity is of liquids, although there is no relation between the two. Freeness may also be defined as rate of drainage of water from stock, but this varies with different types of stock. Stock of one type of pulp at a given consistency may have one "freeness" or rate of drainage. Stock of another kind of pulp at the same consistency may have an entirely different freeness. Freeness is always measured at one consistency and at a standard temperature, since the viscosity of water changes with temperature; and it varies with changes in types of wood, methods of cooking, mechanical treatment, etc. If the freeness varies widely, then measurement of consistency by the rate-of-drainage method becomes meaningless. Freeness of chemical pulp is relatively constant but that of mechanical pulp is not. The control of low consistencies of chemical pulp is much more easily accomplished than control of low consistencies of mechanical pulp.

So far, consideration has been given only to the nature of the stock as it affects valving, flow measurement and consistency control. Mention might be made of the measurement of levels in stock chests or tanks. Here the bubbler pipe level recorder holds its own and it is standard equipment not only on open chests, or chests vented to atmosphere, but on flumes, flow boxes, head boxes, Parshall flumes, etc. The diaphragm type of gage is seldom, if ever, used; that is, the rubber-diaphragm type, not the new metal-diaphragm level transmitters. Bubble-pipe level gages have their limitations; they cannot be used with any degree of satisfaction on stocks having consistencies greater than

2 percent. As we increase consistency, here is less and less free water and the air merely tends to channel up through the stock, giving false records. In using bubble pipes in measuring stock levels, one trouble which often occurs is that of pulp fibres adhering to the inside of the bubble pipe. Over a period of time, enough fibres may accumulate to block the bubble pipe completely. To avoid this trouble, it is common practice to bring a small water line to the top of the bubble pipe and to have a small amount of water trickle down the inside of the pipe to keep it wet and wash down the fibres. A few V notches in the open end of the bubble pipe help to give better records by causing small bubbles to be released more frequently. A recommended set-up is shown in Fig. 19.

Pulp stock, after being washed and screened, may be used without further chemical treatment if so desired, that is, as unbleached pulp, but is usually subjected to further mechanical treatment. If it is to be bleached to improve the color and/or to remove certain constituents which are undesirable in the end uses of the pulp, it goes through several stages of bleaching. In this country, little, if any, groundwood is bleached, but bleaching of chemical pulp, either sulphite or sulphate, is very common. The bleaching process usually consists of a chlorination stage, in which the coloring matter may be oxidized and rendered colorless, or soluble in water; a caustic extraction stage in which other colored compounds are removed, a hypochlorite bleaching stage and often a final stage in which sulphur dioxide is used to prevent reversion of color. There are many variations of the foregoing. In some bleach plants, additional stages of caustic cooking may be added to remove the beta and gamma cellulose which are often undesirable constituents in the end product. It is beyond the scope of this article to discuss bleaching operations further than this sketchy outline but again it is apparent that instrumentation is required and must be considered.

Chlorination has been mentioned and most mills bring in the chlorine from a chemical company who delivers it in tank cars by rail or water. The unloading of chlorine involves some instrumentation and many precautionary measures. The first requirement is clean dry air for unloading the cars into the mill storage tanks; and by dry air is meant air with a dew point down to about —20 F. An air drier of the silica gel type or activated alumina of sufficient capacity is used after an air compressor which is used for no other purpose. Definitely, the mill air supply must not be used as there is always the possibility of chlorine getting back into the mill air lines with attendant danger to the users of mill air and to the lines.

Fig. 20 shows a method of unloading recommended by one of the chlorine suppliers. Note the air compressor, after-cooler, air receiver and air drier. Air pressure is used to force the chlorine into the storage tanks to prevent flashing of the chlorine into vapor as the level in the tank car drops. Since it is desirable to unload at as high a rate as possible without causing the ball check or excess-velocity valve in the tank car to shut, a rotameter is installed in the line to measure the rate which is set by the manually-operated valve. When the car is unloaded and air begins to come through, the float in the rotameter drops and causes a contact to be made, energizing a three-way solenoid valve in the air line to a diaphragm shut-off valve. The valve closes and shuts the line. At the same time a bell or other alarm could be operated to warn the operator so that he might shut off the hand valve. A check valve prevents reverse flow in case of air pressure failure. A sight glass gives visual indication of whether or not chlorine is in the line.

Level alarms are required on the storage tanks and they are set to sound at a point just below maximum safe level so that the operator may switch over from one tank to another when filling. A gamma-ray type of level indicator has been brought out recently and it would appear to have definite applications.

Storage tanks must be fitted with proper relief valves and two relief lines per tank are recommended with the hand valves in these lines geared together, so that should one valve be closed, the other would open. Frangible diaphragms or safety heads are used, set for 50 psig. These are to protect the relief valves from corrosion due to chlorine fumes. A pressure gage in each line between the safety head and the relief valve is installed to indicate if the safety head diaphragm has failed through corrosion.

The metering of chlorine flow presents a problem. A few weeks ago, the writer would have stated that flow measurement was easier to accomplish accurately in the liquid phase. At that time both the suppliers of chlorine and one of the instrument companies supplying rotameters strongly recommended metering in the liquid phase. Now the meter company seems to be reversing its position. Field work would indicate that metering in the liquid phase presents certain difficulties, and it would now appear that they prefer to measure flow in the gas phase. A prominent bleach plant consultant has stated that he too prefers metering in the gas phase. It may be that some recommendations will be forthcoming on this important phase of metering.

Sodium hydroxide, or caustic soda, is also brought in in tank cars at a nominal density of 50 percent. It is heated by means of a steam supply connected to coils in the tank car and pumped to the storage tanks, which are also heated. Before being used in the process, it is diluted to the required density. Whereas formerly the dilute caustic solutions were made up in

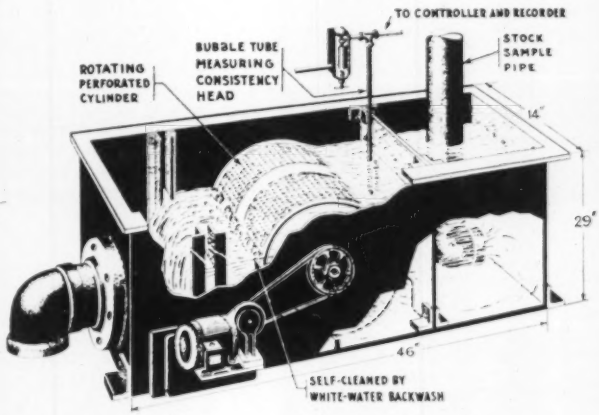


Fig. 17. Askania low-range consistency detector unit.

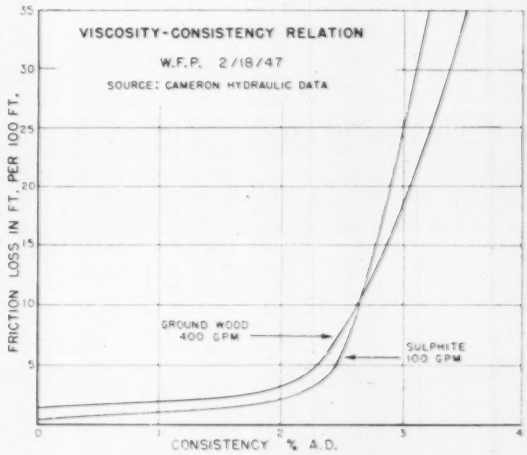


Fig. 18. Viscosity-consistency relation.

(From article by Wilbur F. Pray in *Instruments*, June 1947, pages 539-540, 568.)

batches, it is quite common practice in the new mills to do this on a continuous basis.

The continuous systems may operate on a volumetric ratio proportioning system, or may operate on a basis of the specific gravity of the final dilute solution. Although there are several

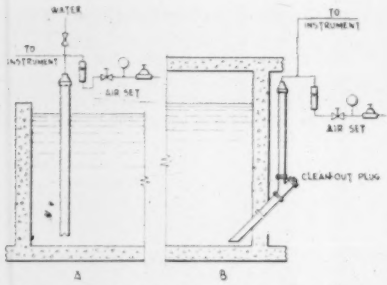


Fig. 19. Typical bubble-pipe installations: (a) In open chest; (b) In closed chest vented to atmosphere.

methods of measuring and controlling the specific gravity, the one illustrated in Fig. 21 is typical of what may be done. In this particular set-up, the flow of filtered water is controlled from a level controller in the dilute caustic tank in accordance with process use. The strong caustic is added just ahead of the mixing chamber. An orifice or check valve in the line to the tank produces a differential pressure and a sample of the mixture flows through a density-measuring device. The float moves up or down as the density changes, causing changes in the output air pressure to a recorder-controller which, in turn, controls the valve in the caustic line. The arrangement of lines to and from the sampling devices tends to eliminate any errors due to velocity effects. Temperature is not compensated for, but any errors due to temperature changes within wide limits are negligible and may be neglected.

Flows of caustic solutions and bleach liquor solutions are commonly measured by rotameters. Dilute caustic presents no special problems, but bleach liquor did for a time. Now, however, proper design and protection of the rotameters give accurate trouble-free metering.

Since rotameters operate best with a constant head on them, it is common practice to use constant level boxes ahead of rotameters. Such an installation is shown in Fig. 22.

In many mills the rotameters are mounted on the instrument panels. Personally, the writer prefers not to have any chemical lines whatever entering the panel and his practice has been to use transmitting rotameters mounted below the head boxes with totalizing recorders mounted on the panel. The flows of chemicals to the solution may be adjusted automatically or the valves may be set remotely by air loading to give the correct setting.

Although only instrument applications in the pulp mill have been considered, any remarks concerning stock flow and consistency control apply equally well to the paper mill. In the paper mill the processing of the stock is largely mechanical. There are refining operations which are designed to alter the physical characteristics of the pulp fibres to give the qualities desired; there are further dirt-removal stages; there are the stages of blending, color

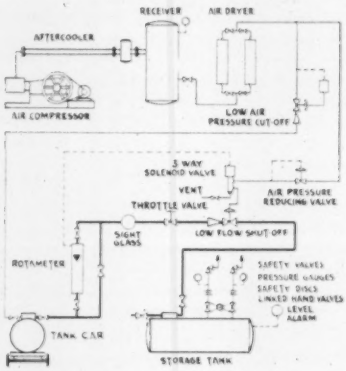


Fig. 20. Chlorine car unloading instrumentation. (Based on Hooker Chemical Co. recommendations.)

addition, etc. The stock is then sent to the paper machine where the sheet is formed and dried by passing over numerous steam-heated cylinders. There are as many systems of drier control as there are paper mills, almost, and it is unnecessary to discuss these as

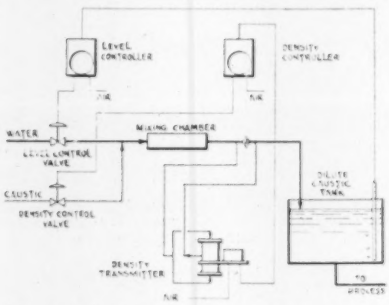


Fig. 21. Caustic dilution system.

information is readily available.

It may be well to touch briefly on instrument air supply systems. Instrument suppliers specify clean dry air at a certain pressure and that's about all the information they give one about the air supply. The matter of instrument air is of prime importance. The compressor should be of substantial construction designed for heavy service. It should be provided with an aftercooler and an air receiver. For regular service, an air drier of the silica gel type may not be required, but if temperatures along the air lines are low and cause condensate to form, it may be well to consider the addition of such a drier.

If the mill is large, an instrument air compressor at each end of the mill may be better than one large compressor centrally located. By interconnecting these, either compressor, running at full load, could carry the whole system. Also, as an additional precaution, the mill air supply could be tied in to be used in case of a breakdown of the instrument air compressors. Usually, the combustion control instruments and equipment in the boiler house have their own compressor. In many mills, with two or more boilers, one boiler may have all its auxiliaries, such as induced- and forced-draft fans, feed-water pumps, etc., operated by steam turbines, so that in case of electrical power failure, this particular boiler will still be able to generate steam. It would seem logical, though expensive initially, to have the boiler-house instrument air compressor also powered by a steam turbine, and this has been done.

Instrument air piping must be considered but this involves no special considerations other than making the air headers large enough and using tubing capable of resisting corrosion where encountered.

As regards panels, these require separate consideration for each job, in fact, for each department in the mill. The term "Packaged Unit" is used often with reference to control systems, but this is something of a misnomer. The framework and cabinet may conform to certain dimensional standards, but the layouts are rarely alike. There is, however, a definite trend toward cabinet panels and toward light colors as op-

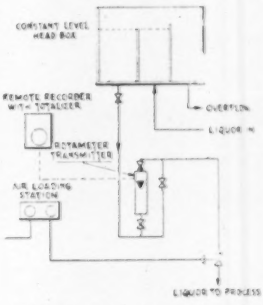


Fig. 22. Typical rotameter installation on bleach liquor line.

posed to the once-standard black. Adequate lighting of the panels is of importance. In some jobs, not only is regular canopy lighting used, but provision is made for emergency lighting from batteries. Console type panels for washers, with sloping tops, are being used to a great extent and make a lovely job. Ventilation of panels, interior illumination of the cabinets, proper tagging of connections are other items of consideration.

This article has covered briefly some points that must be considered in the application of instruments to the pulp and paper processes. There are many others! Adequate instrumentation is essential for efficient and economical operation, but instrument equipment improperly applied can result in loss of production and needless expense. Careful consideration of all factors is truly important.

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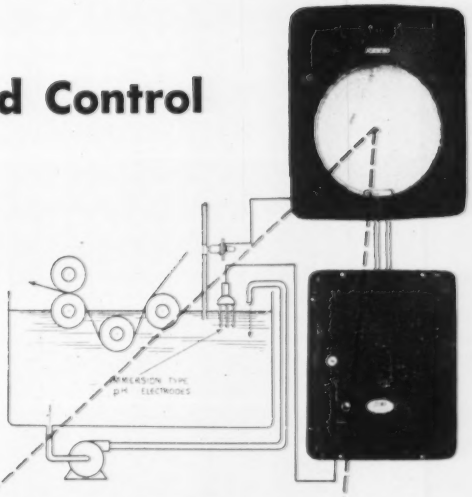

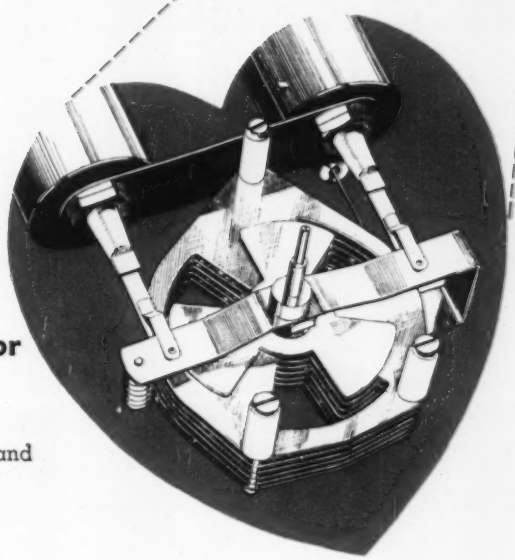

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DYNALOG ELECTRONIC INSTRUMENTS

Some Application Factors Affecting *the* Regulation *of* pH *in* Industry

By ALLEN L. CHAPLIN, Consulting Engineer

X. THE REAGENT

The term *reagent* may or may not fit all the accepted terminologies of control engineers: Some may prefer to call it the "control agent" while others may choose to speak of it as the *manipulated variable* in keeping with ASME terminology. Production personnel of many user industries have established their own mode of identification having strong reflection of the operator's favored brand of humor. Alum is sometimes referred to as "pucker juice" while other reagents have been called "sheet stretcher" and "getter." In one case it was simply "pH" and the operator manipulated his control valves to "turn on more pH." Many operators recognize it as the control chemical but most plant people would look in the recorder case for a "reagent."

The term *reagent* derives from the chemist's terminology to identify a known and calibrated chemical used to evaluate an unknown. Whether this terminology is best fitted to the control engineer's work is a matter requiring special study.

Normally, the reagent is a known chemical of fixed strength which effects a change in pH of the process liquors by virtue of a chemical reaction resulting from admixture of the two. It may be a gas, a liquid or a solid, depending on individual conditions. Some reports have appeared in the literature on the controlled use of ultrasonic energy and ultraviolet light to effect a change in pH, but these methods are not important industrially at present.

A—Liquid Reagents

At least three thermodynamic conditions have bearing on the rate of reaction between reagent and process liquor and may, in some cases, require stabilization to obtain good pH control. Higher temperature usually increases reaction rates of solutions and must be controlled in some cases to obtain satisfactory pH regulation. It has not been uncommon experience in many plants to observe "upsets" or variable effects in pH control with changing seasons: a regulator installed during the summer months would behave quite differently during cold winter months and in some cases could not be adjusted to operate satisfactorily at all. Equilibrium lag, due to chemical inhomogeneity, would make its appearance during winter months but would disappear entirely with the return of the first robin.

Notwithstanding the effects of temperature on resistance of the glass electrode which affects sensitivity of pH measurements,* the above observations were found to be conditions resulting from the effect of temperature on reaction between process liquor and control reagent. In many cases, temperature of processing materials is not regulated closely but is allowed to vary with ambient temperature of the building, or, as in the most serious extreme represented by the paper industry, the processing water (over 95 percent of the total material processed) is usually allowed to vary between extremes of the outside weather. It is not economically feasible in such cases to regulate temperature and it is often regarded unnecessary in terms of over-all results.

The pH control records resulting from such conditions are not unlike Figs. 25 and 25-A although many have been observed having an inhomogeneity band width of 3.0 pH. Conditions within the control loop responsible for such records are not to be regarded as satisfactory but in some cases the final results have been acceptable because of sufficient time element in the process *after* the regulator to permit conditions to reach equilibrium. Although an otherwise defective control record may not be objectionable in terms of over-all results, it does represent defective control and should be corrected in the interest of good control engineering.

It has been necessary in some cases to correct the fault because of unsatisfactory results and, although it was not feasible to heat the process material, other measures have proved effective. In many cases, it has been possible to relocate the equipment at a point of different concentration gradient and eliminate seasonal effects. Of particular interest in this regard is the fact that in every case of such trouble in the paper industry, and a few other industries involving clay and solid suspensions, the inhomogeneity was eliminated by relocating at a point of *lower* concentration of suspended material. One might suspect, therefore, that suspended matter has a property of absorbing reagent or otherwise affecting its contact with reacting liquors, or, possibly, in some cases, of catalyzing side reactions or affecting the forward speed of reactions.

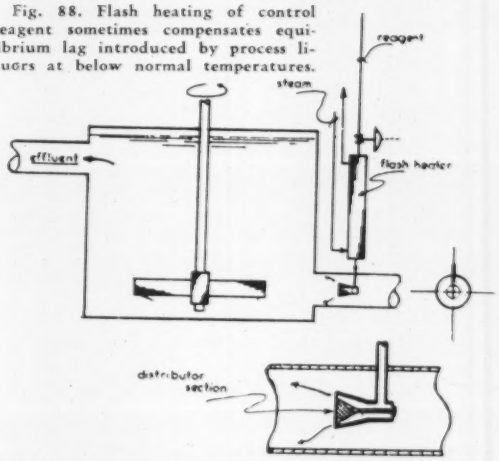


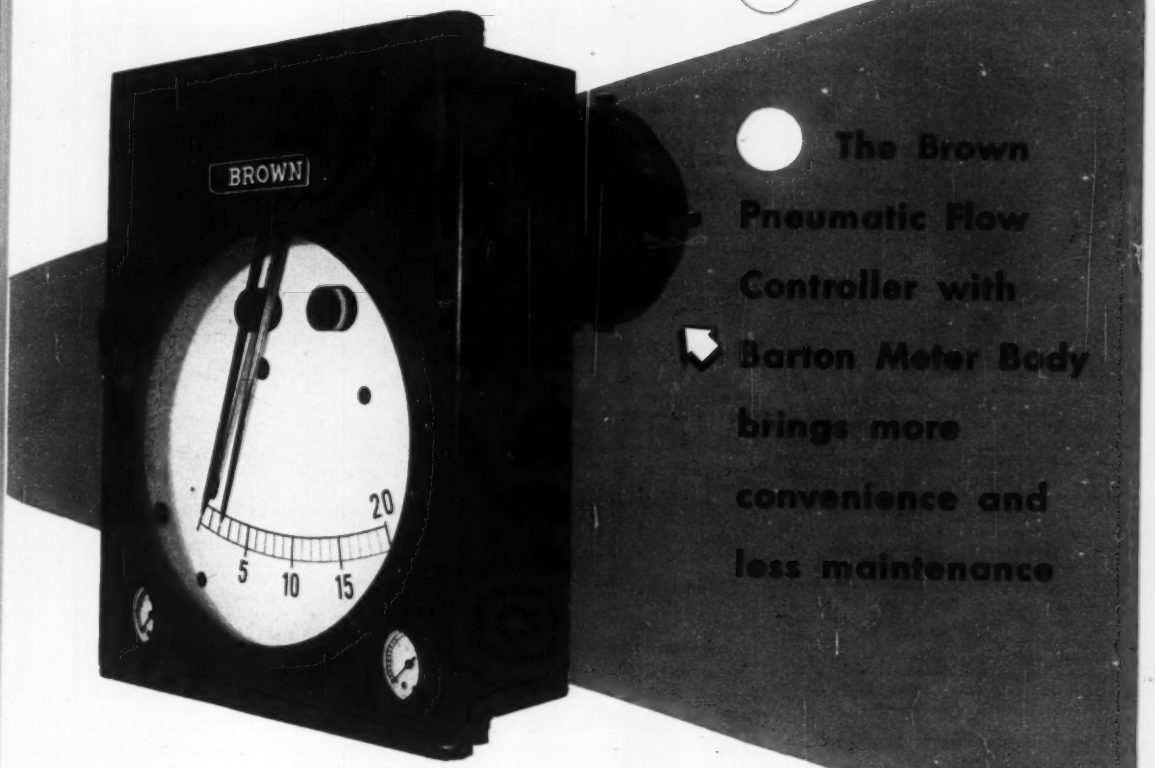
Fig. 88. Flash heating of control reagent sometimes compensates equilibrium lag introduced by process liquors at below normal temperatures.

Some applications in the chemical manufacturing industry have exhibited seasonable characteristics but it usually has not been possible to relocate the control; and other techniques have been called for. In one case, a process liquor was transported through a pipe-line out of doors between buildings 1/5 mile apart and "settled" in an outside tank before processing. It could not be heated economically but in this and other similar cases the equilibrium lag has been eliminated by two combined steps. Firstly, flash-heating the reagent in a steam-jacketed line before it enters the process and, secondly, injecting it into a small cross sectional area of the influent liquor (Fig. 88), has proved to be effective. Some engineers have reported improvement in winter operations by the installation of a flash steam coil in the process liquor at the point of reagent addition: Agitation, not normally required in the summer months, has proved effective in other cases.

The general concept of introducing reagent into a small cross-sectional area of process liquor cannot be overstressed. As above said, the ideal condition of contacting the two liquids so far as uniform distribution goes, would be in thin films approaching molecular dimensions, while the opposite extreme is the addition of a small reagent stream to the body of a large residence system. The majority of pH control installations are probably of the latter type wherein re-

Continued on page 154

* A glass electrode (Corning 015 glass) having a resistance of 1.0 megohm at 60 C. may increase resistance to 15 megohms at 30 C., 50 megohms at 18 C. and 161 megohms at 7 C.



The Brown Pneumatic Flow Controller with Barton Meter Body brings more convenience and less maintenance

Minneapolis Honeywell — *Advanced Instrumentation* FOR BETTER PROCESSING — BROWN INSTRUMENTS

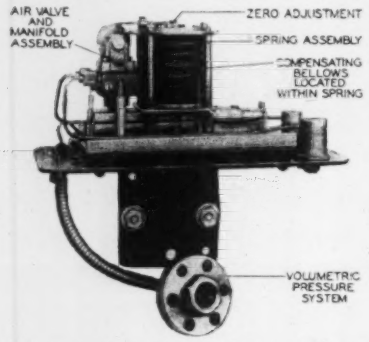
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control — in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 207

Pressure Transmitter

New "Transaire" force-balance type of pressure transmitter is said to "offer for the first time convenience and accuracy of suppressed ranges at high pressure levels." It makes it possible to measure and transmit (up to 1000 feet) small pressure changes with an accuracy of 0.5 percent of range span. Range spans of 20 to 40 psi are avail-

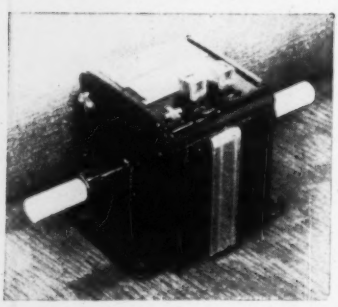


able over range limits of 35 to 415 psia with sensitivity of 0.1 percent or 0.02 or 0.04 psi, depending on range span used. Regardless of pressure range or span, transmitter output is always linear from 3 to 15 psig, proportional to measured pressure with an accuracy of plus or minus 0.06 psi, obviating need for individual calibration of matching receivers or receiver-controllers. Operating ranges can be varied with range limits by screwdriver adjustment; continuous adjustment of any range span can be made within range limits of instrument; range limits can be shifted by changing spring sub-assembly.—*Taylor Instrument Companies, Rochester* 1, *N.Y.*

Mention No. 201 when filling out card.

High-accuracy Indoor Current Transformers

New "Type MR" through-type current transformers for low-voltage metering indoors with or without thermal demand meters have an exceptional accuracy with ASA class 0.3 at burden B-0.1 and a continuous current rating



of 200 percent while not exceeding a temperature rise of 55 degrees C. Accuracy is maintained over this entire current span so that only two current transformers (200- and 400-amp. ratings) are required to meter in complete range from 10 to 800 amps. Use of grain-oriented Hipersil in the core minimizes weight and dimensions. Transformer has metal case with Moldarta cover and removable silver-plated primary conductor. Secondary terminals, mounted on phosphor-bronze supports, have solderless connectors that will accommodate No. 6 to No. 14 conductor. No short-circuiting device is used since open-circuit voltage under full load is only approximately 100 volts. Transformers are for operation up to 600 volts with primary current ratings of 200 or 400 amps. to 5 amps. A three-wire transformer is also available with a ratio of 200-200 to 5 amps.—*Westinghouse Electric Corp., P. O. Box* 2099, *Pittsburgh* 30, *Pa.*

Mention No. 202 when filling out card.

Temperature-limit Cut-out

New "Protect-o-Vane" controller, designed to shut off heating sources when temperatures go beyond a set limit, has many components interchangeable with maker's "Pyr-o-Vane" unit. It can also be used in conjunction with maker's "Electronik" line.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne and Roberts Aves., Philadelphia, Pa.*

Mention No. 203 when filling out card.

Dragless-pointer Automatic Controller

New "Pyr-o-Vane" controller works through action of a light-metal vane, mounted on a millivoltmeter pointer, which moves in and out of an electric field. Features are: snap-action control and non-cyclic correction. Instrument is said to be in low-cost range.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne and Roberts Aves., Philadelphia, Pa.*

Mention No. 204 when filling out card.

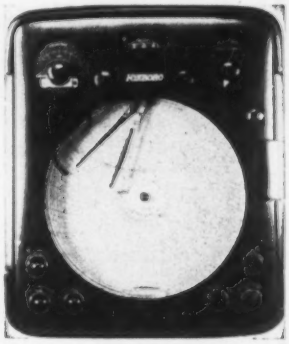
Coating-thickness Gage

New special-purpose "Magne-Gage" measures thickness of nickel coatings on iron or steel in the range of 0.001 to 0.0045 in. by magnetic means, without injuring coating or base metal. This thickness range is beyond that of standard "Magne-Gage" (which measures thickness of nickel coatings on iron or steel from 0 to 0.002 in.) and cannot be supplied on Magne-Gages having other calibrations. Delivery, 30 days.—*American Instrument Co.,* 8030 *Georgia Ave., Silver Spring, Md.*

Mention No. 205 when filling out card.

Time-temperature Controller for Dyeing Processes

New "Model 40 CycleLog" combines features of "CycleLog" controller for automatic control of textile dyeing machines and of "Model 40" controller, making possible a more compact assembly. Three instruments can now be installed in panel width formerly re-



quired by two. All of desired settings for cycle are made by means of four knobs on front of instrument case, including rate of temperature rise and holding period, from 5 min. to 3 hr. When operator pushes Start button, operation becomes fully automatic. At end of cycle, heat supply shuts off and a signal lamp flashes. Beside this automatic push-button feature, two additional timers (adjustable inside case) have been added: Initial Timer to allow dye bath to come to a uniform temperature before start of controlled rate of rise; Duplicater Timer for overtime periods (has a separate push-button).—*The Foxboro Company, Foxboro, Mass.*

Mention No. 206 when filling out card.

Predetermined Electronic Counter

New "Model 133" three-decade electronic counter predetermines any count from 1 to 999 continuously and provides a high-speed relay action each time selected count is reached. Other models having capacities of 2, 3, 4, 5 and 6 digits are available. Rates up to 60,000 per min. may be used. Output consists

of a high-speed mercury-type relay which operates in 2 milliseconds. Several different types of relay actions are available. One type reverses each time selected count is reached. Another type provides adjustable-momentary contact which can be adjusted over a period of 0.1 to 0.01 sec.—*Potter Instrument Co., Inc.*, 136-56 *Roosevelt Ave., Flushing, N. Y.*

Mention No. 207 when filling out card.

Ultraviolet Lamps

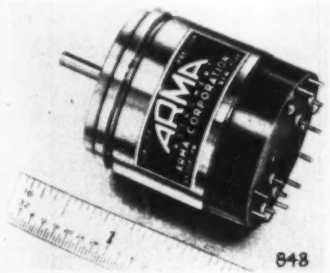
New models of "Mineralight" operate from 110 v. a.c., 110 v. d.c., or batteries. Both short- and long-wave lamps, "streamlined in design" and light in

weight, are easily held in hand. Carrying cases are available which are equipped with a daylight-viewing aperture and a place for batteries.—*Ultra-Violet Products, Inc., S. Pasadena, Calif.*

Mention No. 208 when filling out card.

Electromechanical Resolving Components

New "Size 03 Group"—a series of eight 400-cycle electrical resolvers—now freed from security restrictions, has been released by maker for use

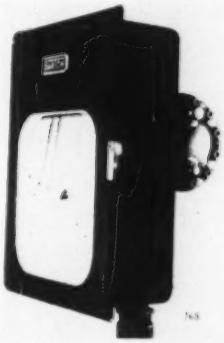


in civilian instrumentation involving trigonometric problems, replacing aggregations of gears, bearings and slides previously used for such purposes. Four of the eight types have zero phase shift and unity ratio between input and output. All types now available in quantities.—*Arma Corp.*, 254 36th St., *Brooklyn* 32, *N. Y.*

Mention No. 209 when filling out card.

Mercuryless Flow-rate Recorder

New "Model 202" flow-rate recorder employs a rupture-proof bellows and torque-tube for measuring differential; features an internal-adjustable pulsation damper. For gas service,

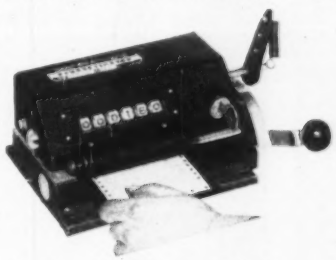


instrument is self-draining in case of liquid accumulation in housing. Bellows-differential mechanism eliminates problem of measured-fluid to manometer fluid contact; torque tube eliminates pressure-bearing problems; and because hydraulic fluid is permanently sealed within bellows, pulsation-damper plugging problems are eliminated.—*Parton Instrument Corp.*, 1429 *S. Eastern Ave., Los Angeles* 22, *Calif.*

Mention No. 210 when filling out card.

Stroke-type Printing Counter

New "Model PVR" counter gives both visual and printed record of counter register on cards, multiple sheets,



etc. using an adding-machine type ribbon. 90 degree throw of lever actuates counter and printing mechanism. Housed in aluminum case and provided with oil-less bearing, counter is rated for speeds up to 500 counts per min.—*Durant Mfg. Co.*, 1914 *N. Buffum St., Milwaukee* 1, *Wis.*

Mention No. 211 when filling out card.

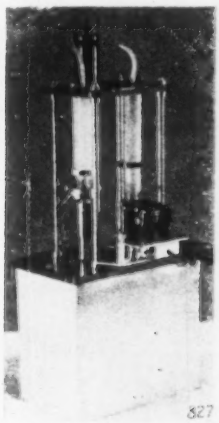
Flame Detector

New "Protectoglo" flame detector, for processes where oil or gas fired burners are used, operates on flame rectification principles; "makes use of the fact that either a flame, or a photocell sighted at a flame, is capable of not only conducting an electric current, but of rectifying an alternating current." System not only provides instantaneous response to flame conditions, preventing a discharge of unburned fuel to combustion chambers, but also incorporates an automatic check of its own components and will shut off fuel supply in event of failure. System can be interlocked with any needed combination of control devices and accessory equipment, such as excess-pressure, low-pressure and low-water safety cutoff, temperature control, alarms, signal lights, etc. It can be used for single or multiple burner installations and is available immediately.—*Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Mention No. 212 when filling out card.

Dual-syringe Feeder

New "Dow Dual Syringe Feeder" provides smooth non-pulsating flow of liquid at constant rates accurately adjustable from 7.6 cc. per hour to a few liters per hour; operates at low pres-

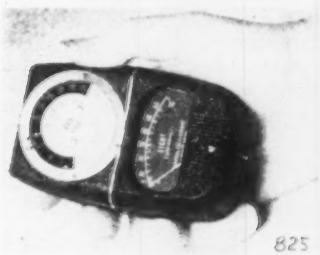


sures (not exceeding 3 psig.); handles most corrosive liquids; is of greatest usefulness in experimental work.—*Modern Metalcraft*, 1075 *N. Eastman Rd., Midland, Mich.*

Mention No. 213 when filling out card.

Exposure Meter

New "Type DW-68" photoelectric exposure meter which supersedes present "Type DW-58" features a sturdier instrument mechanism and a restyled



calculator dial calibrated for American Standard exposure index numbers.—*Meter & Instrument Divs., General Electric Corp., Schenectady* 5, *N. Y.*

Mention No. 214 when filling out card.

Strain-tester for Elastomers

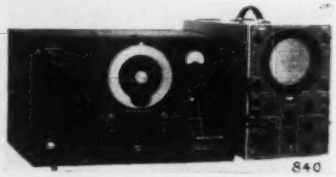
New "GFB-NBS" strain tester measures percent elongation of a virtually motionless specimen in a friction-free mounting a definite time after application of a prechosen stress. Tester measures to about 1000 percent elonga-

tion in 1-percent increments. It induces stresses from 50 to 400 psi. with about 1 percent accuracy, and with additional fixed weights, stresses up to 5000 psi. may be obtained.—*G. F. Bush Associates, Box* 175, *Princeton, N. J.*

Mention No. 215 when filling out card.

Average-speed Indicator

New "Rotalyzer" measures average rotational speed of a shaft and indicates variations in speed vs. time. Equipment includes pickup devices for attachment to shaft, a cabinet containing amplifier and analyzer elements and an oscilloscope (modified DuMont "304 H" applicable to other general

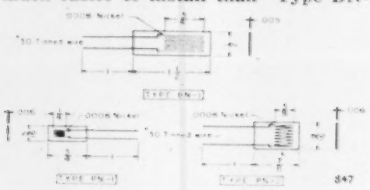


work, or user's own d-c. coupled oscilloscope). A high-frequency magnetic disk and pickup are employed on shaft. A tunable calibrated local oscillator indicates average shaft rpm. in conjunction with a null-reading voltmeter. 'Scope indicates variations in speed (vertical) and time (horizontal). 'Scope horizontal axis may be made proportional to shaft motion. Standard speed range is 900 to 7200 rpm.; may be extended upward to 50,000 rpm. and downward to 33⅓ rpm. on special order. Accuracy of 0.1 percent is available over speed range. Accuracies to 0.01 percent available at single speed in standard instrument.—*Kay Electric Co., Pine Brook, N. J.*

Mention No. 216 when filling out card.

Resistance Thermometer Elements

Two new elements, "Type PN-1 and PN-2," are added to "Stikon" line; are much easier to install than "Type BN-



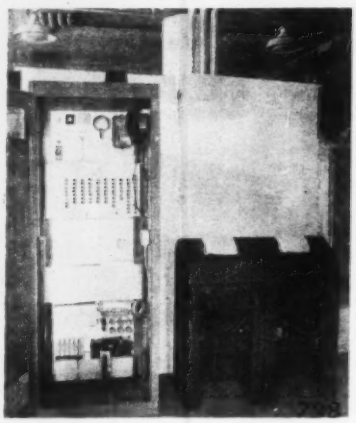
1" and are substantially lower in cost; therefore better suited to experimental applications.—*Ruge-deForest Inc., 76 Massachusetts Ave., Cambridge* 39, *Mass.*

Mention No. 217 when filling out card.

Digital Remote-recording System

New "Metrotype System," using standard Teletype page printer, may be used to telemeter, select in sequence, and record in page form over any distance such measurables as voltage, current, temperature, pressure, fluid flow, etc. Basic instrument is a 0-150-v. d-c. voltmeter with input resistance greater than 300,000 ohms, or 45,000 ohms when used with a rectifier for a.c. Accuracy is within 2 percent of full scale. Data are recorded in continuous role form; sheets can be perforated, a typical record being an 8.5 by 11 in. page, a half-size sample of which is illustrated. Instrument can produce up to twenty good carbon copies. Power requirements from 60-cps. line are 300 watts for rack and 200 watts for printer.—*Metrotype Corp., 525 W. 76th St., Chicago* 20, *Ill.*

Mention No. 218 when filling out card.



METROTYPE SYSTEMS RECORD

GLENWOOD SUBSTATION

LOCATION

LINE CURRENT AND GROUP TOTALS
MULTIPLY READING BY 10 FOR AMPERES

TIME	01	02	03	04	TOT	05	06	07	08	TOT	09	10	11	12	TOT	13	14	15	16	TOT
12:00	13	27	48	33	121	31	44	18	32	125	55	34	40	39	168	56	28	44	27	155
1:00	13	27	48	33	121	33	40	16	28	117	50	31	36	35	152	50	25	35	24	134
2:00	11	23	41	28	103	27	36	16	27	106	47	30	35	33	145	47	24	37	23	131
3:00	11	22	39	27	099	25	36	14	26	101	44	28	33	31	136	45	23	35	22	125
4:00	10	20	35	25	090	23	33	14	24	094	41	26	30	29	126	41	21	32	20	114
5:00	09	18	32	22	081	21	30	12	21	084	37	23	27	26	113	37	19	30	18	104
6:00	09	18	32	23	082	20	29	12	20	081	41	26	31	28	126	40	20	32	20	112
7:00	09	18	32	22	081	19	27	12	19	077	38	21	29	26	104	34	18	29	18	99
8:00	14	26	49	34	123	32	46	18	32	128	57	35	41	40	173	57	28	45	28	158
9:00	14	25	50	34	127	33	46	19	33	131	58	36	42	41	177	59	29	47	29	164
10:00	14	30	52	36	132	34	49	19	34	136	60	37	44	42	183	61	31	50	30	172
11:00	14	29	51	35	129	33	47	19	34	133	59	37	43	42	181	59	30	47	29	165
12:00	14	28	50	34	126	33	46	18	33	130	58	36	42	41	177	58	29	46	28	161
1:00	13	26	47	33	119	31	43	17	31	122	54	34	40	38	166	54	27	43	26	150
2:00	13	27	47	33	120	31	43	17	31	122	54	34	40	38	166	54	27	43	26	150

Portable Permeameter

New "Porta-Perm" portable permeameter (Fig. 1) is for quickly determining horizontal and vertical permeability of core samples at the well or in the laboratory. In conjunction, a preparation kit (Fig. 2), designed also for field or laboratory, cuts core samples into

shapes of 0.625-in. cubes, using two high-speed diamond saw blades. A petroleum solvent and hot plate are included for preparing samples. Prepared samples are inserted into chamber of "Porta-Perm" and, by means of a rubber bulb, air pressure in chamber is increased. As the air passes through

sealed-off sample, pressure drop is indicated by a falling water column and is timed by a stop watch: permeability is then read directly from curves supplied.—*Gueuther Instrument Co., 2420 Bissonnet, Houston* 5, *Texas*

Mention No. 219 when filling out card.

Shaft-hp. Dynamometer

New "Marine-shaft horsepower-hour meter" indicates both power being transmitted to propellers at any instant and total energy expended over a period of time. Self-contained unit which is mounted on ship's propeller shaft measures speed and amount of twisting to which shaft is subjected.

roduct of these two quantities, calculated automatically, gives horsepower and, when multiplied by time, total energy.—*General Engrg. & Consulting Lab., General Electric Corp., Schenectady 5, N. Y.*

Mention No. 220 when filling out card.

Dial Indicators for Transmission Systems

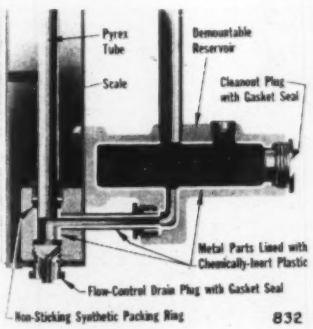
New "Concentric Dial Indicator" for transmitting, receiving and controlling instruments can be read from 50 to 100 ft. Instrument mechanism is easily accessible for inspection or adjustment: by simple rotation of dial. Instrument may be used with only low-pressure-

unit or mercury-manometer actuation for differential or absolute pressure applications. It is available as indicator, indicating receiver, indicating controller, indicating transmitter, indicating transmitter-controller or indicating receiving controller. Standard ranges are 0 to 10 on square-root scale and 0 to 100 and 0 to 200 on uniform scales.—*Taylor Instrument Companies, Rochester 1, New York.*

Mention No. 221 when filling out card.

Reservoir-type Manometers

New reservoir-type manometers feature minimum mercury contamination and easy cleanout, have reservoir and metal passages lined with a thermo-setting plastic, nearly glass-hard and highly resistant to acids, alkalis, thinners, etc.; are regularly available in 14 lengths with scales from 12 to 116 in. long, for use on line pressures

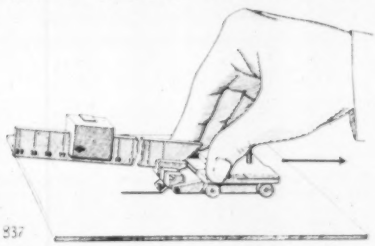


up to 200 psi.; with low reservoir as illustrated, and with raised reservoir for measuring absolute pressure, or for measuring both pressure and vacuum. They can be mounted flush; flat on front of panel; on a wall; or on a bench or table with tripod mounting. Reservoir and connecting parts are steel or brass, or stainless steel on request.—*King Engineering Corp., Box 100, Ann Arbor, Mich.*

Mention No. 223 when filling out card.

Scratch Hardness Tester

New pocket-size "Hoffman Hardness Tester" for testing scratch hardness and adhesion of industrial product finishes provides dependable determinations of pressure on scratching tool

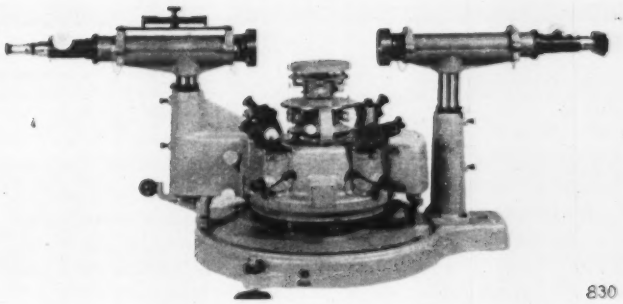


because a reliable lever system reduces friction to one pivot (see illustration). Scale is graduated from 0 to 20; each division equals 100 grams, permitting readings up to 2000 grams with a standard rider (weight) and up to 3750 grams with two standard riders.—*National Paint, Varnish and Lacquer Ass'n, 1500 Rhode Island Ave., Washington 5, D. C.*

Mention No. 224 when filling out card.

Chlorine Feeder

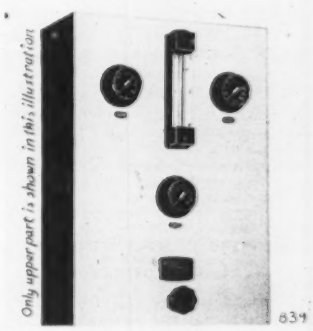
New "Chlorinizer" for feeding chlorine gas features completely safe and highly accurate operation. Chlorine rate indicator with direct-reading linear scale assures equal ease and accuracy



Precision Spectrometer

New "L124" divided-circle spectrometer reads to 1 second of arc, is designed principally for extremely precise determinations of refractive indices and dispersion, and for measurement of prism and wedge angles. Graduated circle, read by means of four special micrometer microscopes, can be turned independently of other parts mounted on central shaft so that measurements can be made on any portion of circle. A gearing system which moves prism table at half the speed of the telescope can be engaged, if desired, when measuring refractive indices by constant-deviation method and of opaque materials by polarization. A camera attachment, polarizing attachment, Babinet soleil compensator, and infrared attachment are offered as accessories.—*Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.*

Mention No. 222 when filling out card.

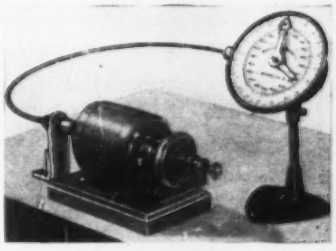


of readings at all rates. Maintenance due to corrosion is minimized because chlorine is controlled and metered in the dry, inert state. New feeder is readily adapted to semi-automatic, program or automatic proportional operation and conversion from one method of operation to any other may be made in the field.—*Builders-Providence, Inc., Providence 1, R. I.*

Mention No. 225 when filling out card.

Quarter-turn Coil-winding Counter

New "Quarter-turn Clipper" counts to speeds of 10,000 turns per min. Equipped with a 6 in. dial calibrated in quarter turns, which indicates 2500 turns and repeats, it automatically de-

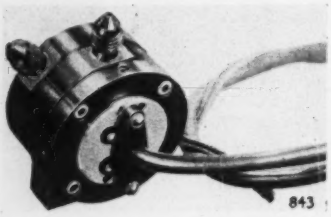


ducts turns taken off coil in case of overrun. Pointers may be reset to zero with one quick motion. Tilting dial affords adjustment to most advantageous angle.—*Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.*

Mention No. 226 when filling out card.

Pressure Pickup for Telemetering

New sub-miniature telemetering pressure pickup, for use in AN/DKT-3 or other FM/FM telemetering systems, has total range from 0 to 400 psi.; may be used for any value of full-scale range from 5 psi. to 200 psi.

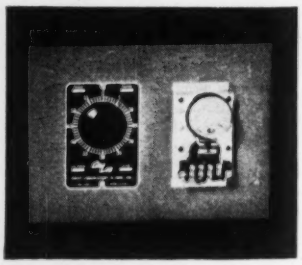


for measurement of differential pressures. Where one chamber is sealed with a reference pressure, it may be calibrated for any value of full-scale range of 5 to 400 psi. Natural frequency is 500 to 2000 cps. Response time depends upon length and diameter of connecting tubing. Acceleration error is said to be negligible. Weight 0.32 lb. —*Pacific Div., Bendix Aviation Corp., North Hollywood, Calif.*

Mention No. 227 when filling out card.

Two-circuit Timing Controllers

New "Models 179 and 180" interval timers can be set for any interval from 0.25 sec. to 15 min. or 1 sec. to 1 hour respectively in 1 sec. increments. Both



models are available in s-p, d-t, or d-p, d-t actions to handle 10 amp. at 115 v. Timers switch one circuit off and one circuit on at end of time interval.—*Dimco-Gray Co., 207 E. Sixth St., Dayton 2, Ohio.*

Mention No. 228 when filling out card.

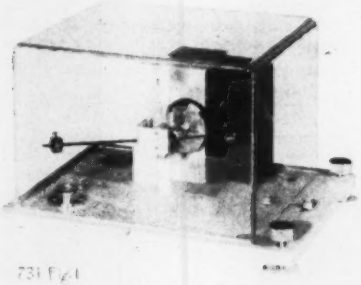
High-temperature Mercury-filled System

New 1200 F. mercury-filled thermal system for industrial processing provides simple, dependable means of measurement and control of temperatures above conventional 1000 F. range limit. Among applications: gas-fired ovens, annealing ovens, high-temperature blanchers, exhaust gases, etc. Among features: newly-developed Bourdon spring, Type 347 stainless steel thermal element, compensation for varying case and ambient temperatures and uniformly graduated charts. Range spans of 1000 F., 600 F. and 400 F. or equivalent Centigrade are available in all maker's standard indicating recording and controlling instruments. No system can be furnished in which range starts at temperatures below 700 F.—*Taylor Instrument Companies, Rochester 1, N. Y.*

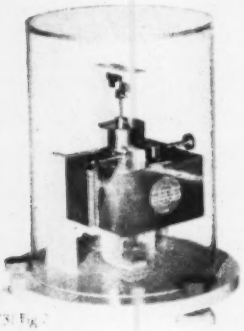
Mention No. 229 when filling out card.

Pulse Magnetic Seismograph

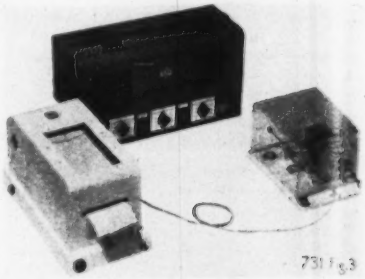
New "Series VR" remote-controlled Visual Recording Seismographs, for recording earthquakes and artificial earth tremors, embody a pulsing system which has solved the difficult problem of stable electronic amplification of low-frequency vibration. A pulse train



with a fundamental frequency much higher (at least 10 to 15 times) than highest harmonic to be recorded is superimposed onto seismometer impulse signal. Amplitude of pulses, kept constant, is so chosen that maximum seismometer amplitude never exceeds pulse amplitude. A rectified portion of combined signal is amplified by a standard a-f. amplifier which raises "modulated pulse signal" to a sufficiently high



level. High-level output of amplifier is then rectified and mixed with rectified signal of unmodulated pulse. This combined signal is then presented to the electromagnetic ink recorder which will record algebraic sum of modulated and unmodulated pulse amplitudes provided that no phase shift takes place between the two signals. Thus, stable magnifications of seismometer output, from 3 to 20,000 or even more, are readily obtainable. Fig. 1 shows "VR-10" vertical-component seismometer; Fig. 2 shows "VR-20" horizontal-component seismometer; Fig. 3 shows "VR-30"

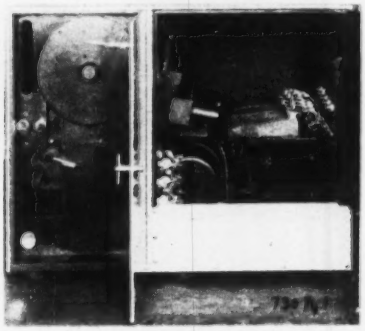


with "VR-30" amplifier and "VR-40" recorder.—*Sprengnether Instrument Co., 4567 Swan Ave., St. Louis 10, Mo.*

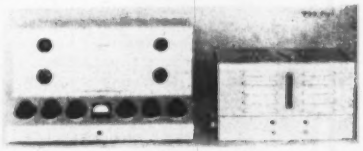
Mention No. 230 when filling out card.

Variable-area Recording and Reproducing Instruments

New multi-trace galvanometer recorder (Fig. 1) and reproducer (Fig. 2), developed to measure seismic wave forms, use variable film-area record-



ing. Recording and reproduction of vibrations may thus be made for electrical-wave analyses, driving shaking systems, or other purposes. Five- to eight-trace equipment is available.



Specifications are: Frequency range, 5 to 300 cps.; Recording film width, 5 in.; Recording and reproducing speed, 8 to 16 in. per sec.; Recording sensitivity, 1.3 cm. per ma.; Reproducer output, 10 microvolts to 1 millivolt into 500 ohms.—*Seismograph Service Corp., 709 Kennedy Bldg., P. O. Box 1590, Tulsa 1, Okla.*

Mention No. 231 when filling out card.

High-intensity Light Source

New "Type-A" mercury-arc lamp has output of 65 lumens per watt; with power input 2 kw. or 1.2 amp at 1750 volts, intensities of 90,000 candles per sq. cm. are attained. Dimensions are 2.85 cm (1.125 in.) by 1 mm (0.039

ALNOR THERMO-ANEMOMETER Here's a compact, direct-reading instrument that fills a long-felt need—the accurate measurement of low air velocities. With the Alnor Thermo-Anemometer you can accurately read velocities as low as 5 f.p.m. It can be used between 20°F. and 150°F. without impairing its accuracy. Fine craftsmanship, high-quality materials, exact calibration, and exhaustive tests combine to assure you accurate operation on a wide variety of applications.

ALNOR ELECTRONIC TEMPERATURE CONTROLLER . . . is a simplified form of controller designed to indicate and regulate automatically the heat of any industrial heating device. There are no moving mechanical parts to wear or cause trouble. Control sensitivity is such that pointer movement of 0.3% will activate the power relay. Available with a wide variety of thermocouples and in scale range from 0-500 to 0-3000°F.

ALNOR DEW POINT INDICATOR . . . for simple, rapid dew point reading of any gas. Indication takes place in an enclosed observation chamber under accurately controlled conditions. Dew or fog suspended in air—not on mirrored surface—makes it easy for two or more observers to get same accurate results. The Alnor Dewpointer is a complete, self-contained unit—no external coolant or other apparatus is required. Available for dew points from —80° F. to room temperature.

ALNOR TYPE 2300 SURFACE PYROMETER . . . sets a new high in precision measurement of low surface temperatures. Special design, from Alnico magnet to the finest, quick reacting thermocouple, assures unfailing accuracy . . . speed and dependability. This is a self-contained, sturdy unit—easily carried and used anywhere on a wide variety of applications. Direct reading, six-inch mirrored scale is easily read . . . quickly understood. The instrument is available in 5 Fahrenheit scale ranges with a span as small as only 150°.

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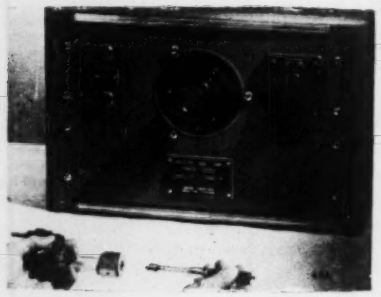
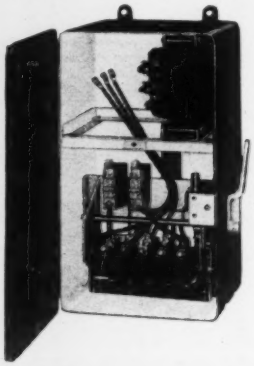


in.). Cooling requires 2.5 gpm. ordinary tap water. Average life at rated max. is 5 hours, appreciably more at reduced voltages. 100 percent intensity is reached at 4358 Angstroms with an 80 percent peak, at 5461 A. and a 73 percent peak at 4047 A., with a max. radiation of 0.08 watts per ster-radian per Angstrom. Intermediate areas average approximately 35 percent.—*Huggins Laboratories, 706 Hamilton Ave., Menlo Park, Calif.*

Mention No. 232 when filling out card.

Motor Starter

New "Bulletin 646" manual autotransformer-type starter for squirrel-cage motors is available in four sizes from 5 hp, 220-440-550 v, to 250 hp, 450-550 v; for 25, 50, and 60 cycles. Two automatic reset overload relays are standard equipment. Available in "Form T" with aid-break contacts; and "Form X" with oil-immersed con-

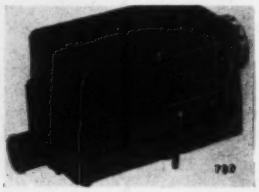


tacts. Air-break form can be converted to oil-immersed operation. A time-delay under-voltage release, which prevents unnecessary opening of switching mechanism on slight voltage dips, is standard on largest size; can be supplied as an optional feature on smaller sizes. All starters have an adjustable time-delay mechanism for controlling length of accelerating period before switching motor from starting to running taps.—*Allen-Bradley Co., Milwaukee, Wis.*

Mention No. 233 when filling out card.

Synchronous Camera

New "Model III" 16-mm. synchronous cameras are used for photographing simultaneous events at remote location. With shutter speeds of 5, 10, and 20, or 4, 8, 16, and 32 frames per second, or with single exposures, synchronization within 1 millisecond is provided by external pulse circuit. Cameras will operate over temperature range of –50 to 110 F, up to 40,000 ft. altitude, and over 100,000 operations without noticeable wear.

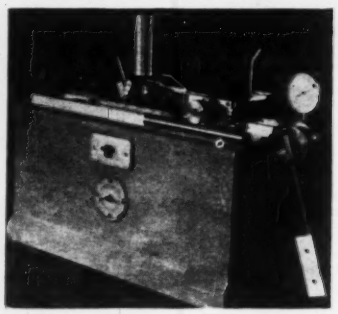


Weight is 4 lb.; size is 7 by 3.56 by 3.5 in.; power needed is 12 watts at 28 v. d.c. plus 0.12 amp. at 1.5 v. for coding and timing lights.—*Flight Research Engineering Corp., P. O. Box 1-F, Richmond 1, Va.*

Mention No. 234 when filling out card.

Film-adhesion Tester

New "Adherometer" measures stripping force, in dynes, needed to remove a paint film from surface of a metal test panel. Stripping is done with hard-



ivory tool, and force required is transmitted through lever system to indicating gage, the reading of which is translated into dynes with a conversion table.—*Henry A. Gardner Lab., Inc., 4723 Elm St., Bethesda 14, Md.*

Mention No. 235 when filling out card.

Machine-control Centers

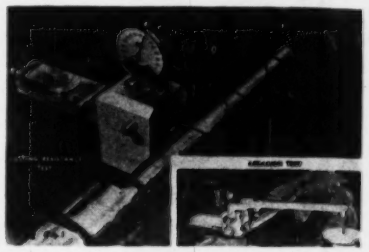
New standardized control centers, containing motor starter units for centralized control of groups of machines, feature plug-in type disconnects on line side for safety. All starter units are 20 inches wide by 20

inches deep, with heights in multiples of 14 inches (for standard indoor structures either 76 or 90.375 inches high); can be mounted back-to-back; can be locked in a positive tilt-out position, disconnected from line; are baffled from each other for added safety in keeping short circuits localized. Provision is made to vent hot ionized gases created by short circuits.—*Westinghouse Electric Corp., Box 868, Pittsburgh 30, Pa.*

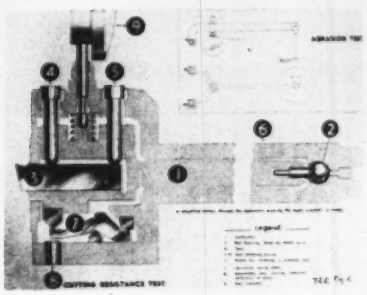
Mention No. 236 when fillling out card.

Machinability Tester

New "M.S.E. Schlesinger" machinability tester measures specific cutting resistance of a standardized cutting tool for a standardized chip area in pounds per 0.001 sq. in. and abrasiveness effect of same work material on



a hardened calibrator by measuring abraded flat on a standardized 10-mm. test ball brought into contact with work material under a known pressure and for a given duration of time. Actual wearing effect is thus stimulated on a standard test ball. Unit consists



of: Dynamometer with indicator, including calibration beam and 11 standard weights; Abrasiveness attachment with mm. magnifier and one half gross 10 mm. test balls; Set of 8 standardized carbide-tipped cutting tools; Fixture for maintaining tool angles, and Fixture for maintaining nose radius of tools.—*Vanton Equipment Corp., Empire State Bldg., New York 1, N. Y.*

Mention No. 237 when filling out card.

Fatigue-testing Machine

New "SF-10-U" fatigue-testing machine applies alternating-vertical forces up to 5,000 lbs. at a frequency of 1800 cpm. and max. amplitude of 0.5 in. Load accuracy is within 2 percent of load or 0.4 percent of capacity, whichever may be greater. Drive is a 2 hp. synchronous motor. Machine will maintain static preloads up to 5000 lb. during tests. Preload is automatically reset to predetermined value whenever

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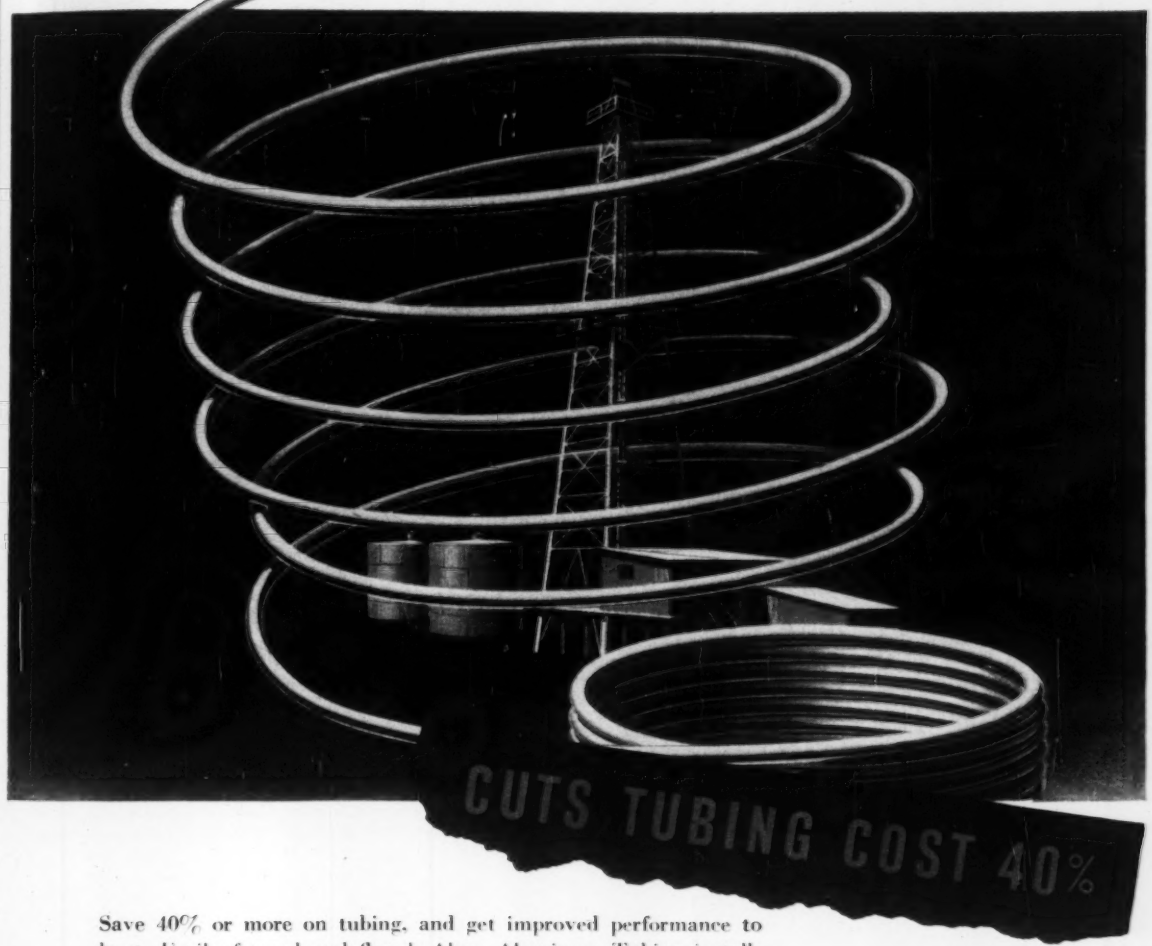

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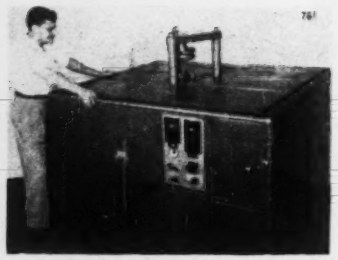
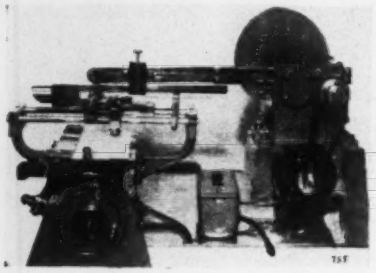


an electrical contact is made by a slight change in length of calibrated loading springs. Floor space 59 by 67 in.; work table 44.5 in high.—*The Baldwin Locomotive Works, Philadelphia* 42, *Pa.*

Mention No. 238 when filling out card.

Scratch-hardness Tester

New "Arco Microknife" measures scratch hardness of a surface coating by totalizing load on, and number of

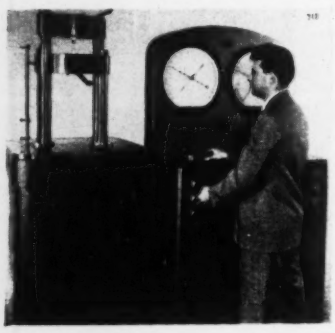


strokes needed for a diamond-pointed tool to wear through surface. Adhesion is measured by applying a standard stress to tool making cuts with successively smaller spacings until coating between cuts is displaced.—*Henry A. Gardner Lab., Inc., Bethesda, Md.*

Mention No. 239 when filling out card.

60,000-lb. Testing Machine

New "Model 60-8" testing machine has a lower gripping-head range of 17 in. at 10 in. per min. Loading controls give infinitely-variable speed between 0 and 2 in. per min. Automatic-safety devices protect gages against overloads and prevent over-travel of moving parts. Vertical distance between gripping heads may be 1 to 18 in. Clear lateral space between columns is 10 in. Table is arranged for standard transverse tools at spans of 12, 18

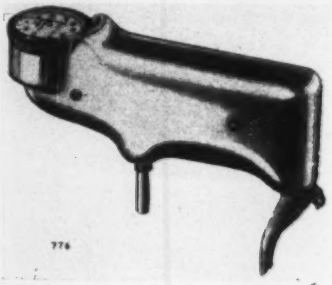


and 24 inches. 60,000 lb. range is graduated in 100 lb. and 12,000 lb. range in 20 lb. units. Bourdon gages for both ranges have accuracy within 1 percent, or one dial division, whichever is greater.—*The Baldwin Locomotive Works, Philadelphia* 42, *Pa.*

Mention No. 240 when filling out card.

Portable Hardness Tester

New "Impressor" hand hardness tester, suitable for spot checking of plastics or non-ferrous metals, is de-

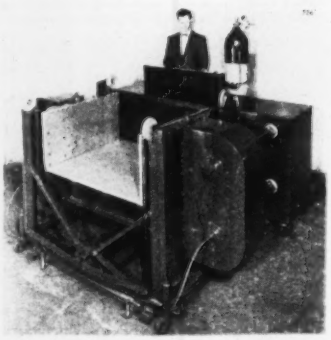


signed for use in any position, in any area which will permit access of operator's hand. Readings may be taken by inexperienced personnel. Dial directly indicates material hardness.—*Barber-Colman Co., Rockford, Ill.*

Mention No. 241 when filling out card.

Vibration Test Stands

New vibration test stands designed for two-dimensional vibration of loads up to 500 pounds make it possible to test specimens under conditions of constant amplitude, as well as con-

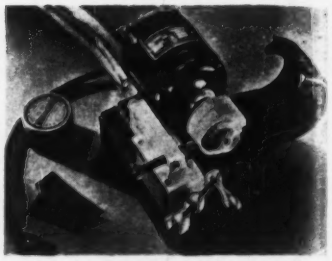


stant force or constant *G*. Machines are semi-portable and require no concrete base. Turntable to obtain third direction of vibration is available. Frequency from 3 to 60 cps., and excursion from 0 to 0.5 in. are controlled from panel. Machines for loads up to 2000 lb. can be furnished.—*L. A. B. Corp., 31 Union Pl., Summit, N. J.*

Mention No. 242 when filling out card.

Refacer for Abraser Wheels

New diamond refacer for trueing small abrasive wheels ranging in size from 1.75 to 2.25 in. is driven by a precision 115-v., 50-60 cps. totally-enclosed motor, with diamond-bored bearings, and base is equipped with

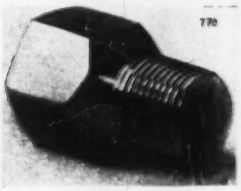


connection for suction unit to carry off abrasive particles.—*Taber Instrument Corp., 111-1 Goundry St., North Tonawanda, N. Y.*

Mention No. 243 when filling out card.

Pressure Snubbers

New "Micro Metallic Corporation" Monel pressure snubber is addition to maker's line of stainless steel and brass snubbers. Mean pore diameter

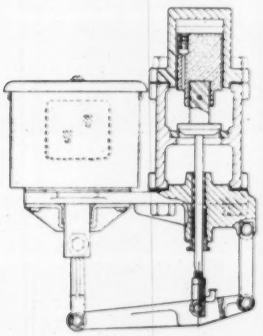


of porous element recommended for gases is 0.0002 in. and this element can be used for fine filtrations. Snubbers are provided in four porosities for use with oil, water, gas and with mercury manometers. Snubber is provided with 0.25 in. n.p.t. and 0.5 in. n.p.t. connections, and fits directly onto a 0.25 or 0.5 in. pipeline.—*Chemiquip Co., 193 Bradford St., Brooklyn 7, N. Y.*

Mention No. 244 when filling out card.

Solenoid Valve

New "Series No. 4000" solenoid valve, designed for normally-closed operation, features a dash-pot which slows down closing action of valve 1.5 to 2 sec. Valve handles temperatures up to 400 F., and smaller sizes will operate under differential pressures up to 150 lbs.

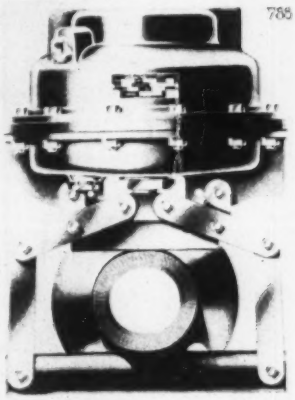


Solenoids are rated to provide unusual reserve factor. Standard construction has cast-iron body with bronze piston; all bronze can be furnished. Valve and seat are stainless steel. Available in 0.75, 1, 1.25, 1.5 and 2 in. sizes.—*Johnson Corp., Three Rivers, Mich.*

Mention No. 245 when filling out card.

Diaphragm-motor Pinch-type Flexible-wall Valve

New "Types 7300 and 7400" pinch-type valves are available in sizes from 1 to 10 in. for 125 lb. duty. Tube, made of rubber, Neoprene, Buna N, Buna S, or Butyl, is anchored to ASA flanges, and completely free of clogging or



bubble formation. Available in normally open or closed style, valve is provided with checks on air lines to allow continued operation in event of temporary air supply failure. "Type 7300" is standard, while "Type 7400" has nearly twice the diaphragm area.—*Flexible Valve Corp., Palisades Park, N. J.*

Mention No. 246 when filling out card.

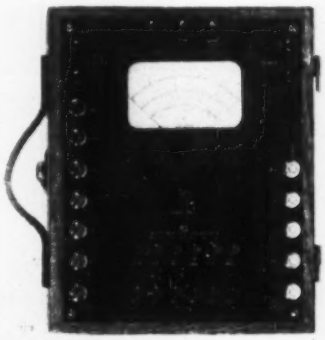
Non-lubricated Cylindrical Control Valve

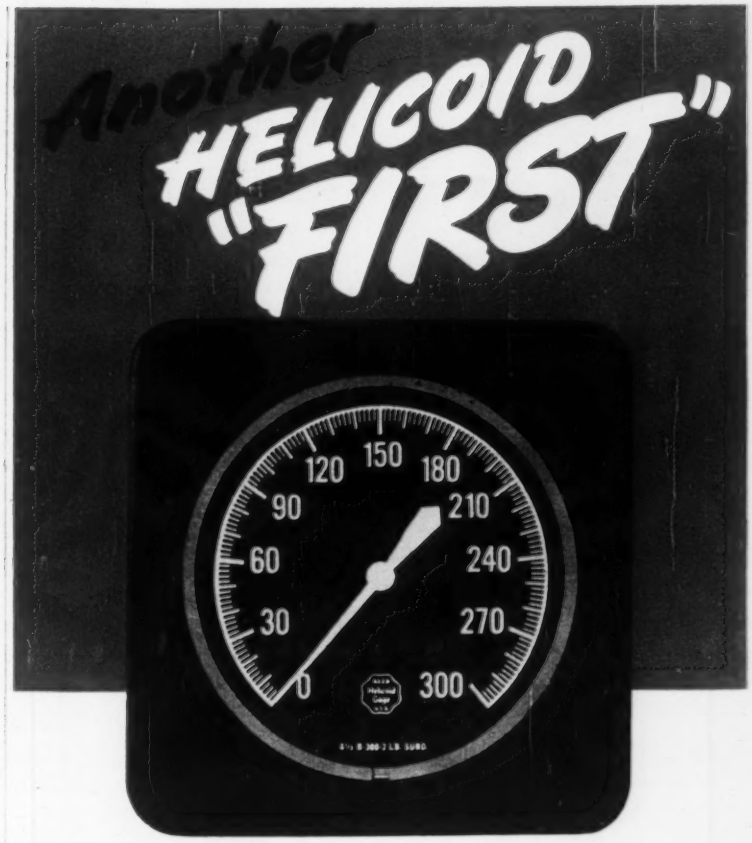
New non-lubricated cylindrical plug industrial control valve, providing leak-proof shut-off while eliminating contamination, includes a permanent seal at plug stem, sealing packing at base of plug, and a fixed-load spring, combined with close dimensional tolerance and micro-finish on plug and body bore. —*Belfield Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

Mention No. 247 when filling out card.

Multi-purpose Electrical Tester

New "Model 102" analyzer covers ranges to 50, 100 mv. d.c.; 1, 5, 25, 125, 250, 500 v. d.c.; 5, 25, 125, 250, 500 v. a.c. at 1000 ohms per volt; 1, 10, 50, 250 ma. d.c.; 1, 5, 25 amp. d.c.; 250 ma.





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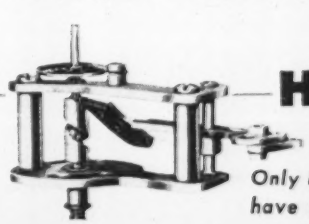

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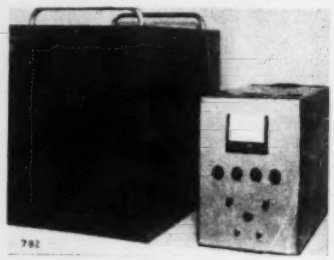
a.c.; 1, 5, 25 amp. a.c.; 0 to 1000 ohms with 45 ohms center scale; 1000 ohms to 1 megohm with 4500 ohms center scale. Accuracy on d.c. is 2 percent, on 60-cps. a.c. 3 percent, and on 25- to 600-cps. 4 percent. Indicator scale length is 3.5 in.—*Instrument Laboratories, 315 W. Walton Pl., Chicago 10, Ill.*

Mention No. 248 when filling out card.

Regulated D-c. Power Supply

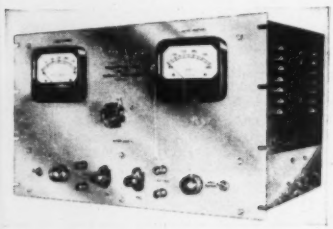
New "Type EME-2" regulated d-c. power supply furnishes 10 to 50 kv. with max. current of 2 ma. Supply consists of a driver unit and a rectifier unit, with either positive or negative ground. Outut voltage can be continuously varied. Voltmeter on front panel of driver unit indicates output for any setting. Ripple is held to a maximum of 5 volts. Each unit weighs 75 lbs. Rectifier unit is 25 in. high, 20 in. wide, and 28 in. deep.—*Engineering Products Dep't, Scientific Instrument Sec., Radio Corp. of America, Camden, N. J.*



Mention No. 249 when filling out card.

Regulated D-c. Power Supply

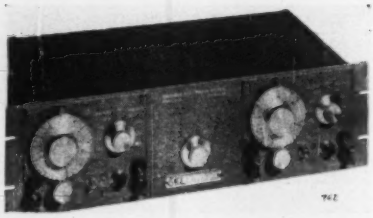
New "Model EA-50A" regulated d-c. power supply is continually variable in output voltages from 0-500 d.c. Ripple is less than 10 mv. Other features are: Power input, 105-125v., 60 cps.; 6.3 v. at 10 amp. (non-regulated) a-c. output; 1 percent regulation between 30 and 500 v. 2 percent regulation between 10 and 30 v. Unit is mounted in relay rack or cabinet.—*Chatham Electronics Corp. 475 Washington St. Newark 2, N. J.*



Mention No. 250 when filling out card.

Variable Electronic Filter

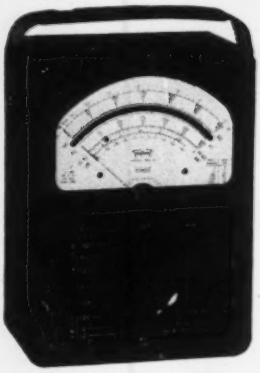
New "Model 302" dual-section variable electronic filter has a continuously-variable cutoff from 20 cps. to 200 kc. Each section has an attenuation rate of 18 db. per octave, and sections can be cascaded to provide 36, 54, etc. db. attenuation. A range switch selects type of section desired, high-pass or low-pass, as well as four decade-frequency ranges. Any bandwidth between 20 cps, and 200 kc. can be selected.—*Spencer-Kennedy Labs., Inc., 186 Massachusetts Ave., Cambridge 39, Mass.*



Mention No. 251 when filling out card.

Volt-ohm-mil-ammeter

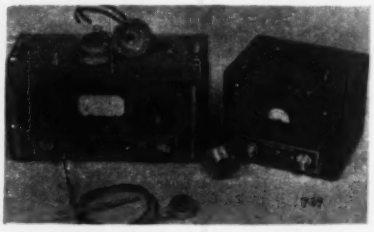
New "Model 630-A" laboratory-type volt-ohm-mil-ammeter with mirrored, hand-drawn scales on 5.5 in. indicator has six d-c. volt ranges from 0 to 6,000, at 20,000 ohms per volt; six a-c. volt ranges from 0 to 6,000, at 5,000 ohms per volt; five d-c. current ranges; decibels; output; and resistance ranges from 0 to 100 megohms, (compensated for greatest accuracy). Resistors, shunts, rectifier, batteries are housed in a molded base integral with switch.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*



Mention No. 252 when filling out card.

Constant-frequency Generator

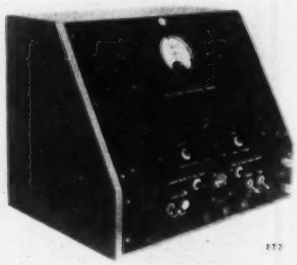
New "Correlator," essentially a constant-frequency signal source with a variable-intensity output which is metered and fed to a specially-designed vibration head, permits feeding to vibration-measurement devices, a vibration of known frequency and intensity. An acceptable standard of noise or vibration can be expressed in terms of instrument output and can be reproduced at will, regardless of variation of line voltage, temperature, humidity, location, etc.—*Aircraft Electronics Associates, Inc., 1031 New Britain Ave., Hartford 10, Conn.*



Mention No. 253 when filling out card.

Line-operated Resistor-testing Bridge

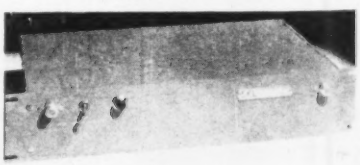
New Resistance Percentage Bridge, designed for testing and calibrating precision voltage-dividing resistors, measures the percentage of total potentiometer resistance tapped in at any mechanical setting of the resistor wiper arm. Accuracy is better than 0.01 percent at all settings from 0 to 100 percent of total resistance. Instrument incorporates a modified Wheatstone bridge circuit, matching voltage drop across selected standard resistors against the voltage drop across a resistor under test. Accuracy is not affected by the rating of resistor under test or by normal variations in supply voltage. Instrument operates from 110-volt a-c. power or from a low-voltage d-c. source. Plug-in connections are provided for an external galvanometer.—*Specialties, Inc., Skunks Misery Road, Syosset, L. I., N. Y.*



Mention No. 254 when filling out card.

40-240-Mc. Amplifier

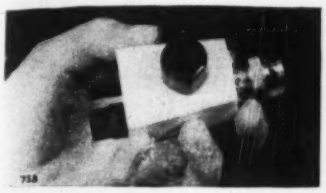
New "Model 212TV" amplifier, designed for television use, is a single untuned amplifier having a bandwidth of 40 to 240 Mc. and a gain of 20 db into a 72 ohm unbalanced load, and 25 db into a 300 ohm balanced line. Capable of replacing up to twelve single-channel TV or FM amplifiers, it has a transmission characteristic within 2 db over bandwidth and an impedance of 200 ohms. Transformers can be supplied to match 52, 72, and 93 ohm unbalanced and 300 ohm balanced lines.—*Dept. I, Spencer Kennedy Labs., Inc., 186 Massachusetts Ave., Cambridge 39, Mass.*



Mention No. 255 when filling out card.

Sweep-generator-output Adaptor

New "Type ST-8A" balanced output adaptor, developed for use with maker's "Model ST-4A" sweep gener-



ator, makes balanced output available; has been designed to give flat and balanced output when working into a 300-ohm resistive load. Vernier output control of sweep generator, normally incorporated in output cable, is incorporated in adaptor.—*Commercial Equipment Div., General Electric Co., Syracuse, N. Y.*

Mention No. 256 when filling out card.

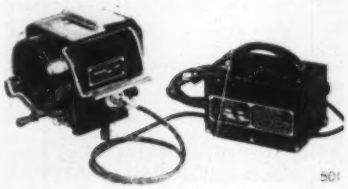
Signal Calibrator

New "Electro-Cal" signal calibrator, using power-line frequency, provides 60 cps. sine wave voltages in 8 continuously-variable ranges from 0 to 1000 mv., and one 0-5 volt range. Output is read directly on millivoltmeter scale with proper multiplier used. Sensitivity is 1000 ohms per volt.—*Industrial Electronics Inc., 2457 Woodward Ave., Detroit 1, Mich.*

Mention No. 257 when filling out card.

Dual-operated Insulation Tester

New combination hand-crank and rectifier-operated insulation tester consists of "Meg" type constant-pressure test set and a separate rectifier which



supplies 500 v. d.c., from any 115 v. a.c. 60 cps. outlet. One cord from hand-crank instrument and another from rectifier to an a-c. outlet eliminates hand operation.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

Mention No. 258 when filling out card.

High-resolution Count Detectors

New "Models 607 and 608" high-speed photo-electronic count detectors are housed in cast aluminum for industrial usage. "Model 607," contained in two identical housings, by interchanging lenses of units gives a parallel beam of 0.5 in. dia. which can be used at distances up to 6 feet or a focused spot, 0.125 in. dia., obtained when two units are 6 in. apart. "Model 608" is an integral unit. A fine focused

Rust and Corrosion spell death to accuracy. Read how this watch manufacturer* eliminated these hazards!

MOISTURE FORMATION . . . like that which damages your instruments . . . once forced a famous watch manufacturer *to scrap precision parts* worth thousands of dollars each week. Part of the solution was a Kemp Dynamic Dryer to dry compressed air to a final dew point of 0° F. Now, the moisture problem is gone and production increased!

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Kemp Dynamic Dryers are flexible . . . offer *manual, semi-automatic* or *automatic* operation. Desiccant is especially selected and compounded for the particular duty. Units are available for drying *air, gases* or *liquids* . . . for controlling humidity in large or small areas. Choose gas, electric or steam regeneration . . . with or without cooling units.

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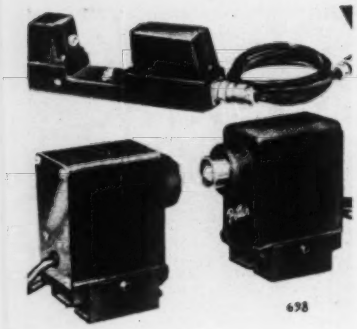


spot 0.0625 in. dia. is obtained midway between light source and detector. Parts as small as 0.001 in. balance wheel screw have been counted. Detectors are completely sealed and provide pulse output which is required to operate high-speed electronic counters.—*Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.*

Mention No. 259 when filling out card.

Alpha-particle Counter

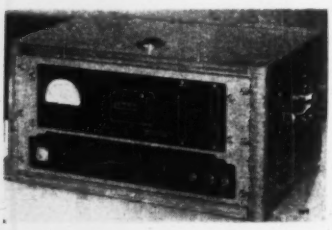
New "Model 2111" portable alpha-proportional counter detects only alpha in presence of other radiation, and includes an integrating circuit to show

average-count rate on a built-in meter. Several types of probes are available. A pushbutton is provided to reset meter after exposure to a strong alpha source. A feature is the plug-in four-tube circuit which is easily removed for servicing. Weight is sixteen pounds.—*Nuclear Instrument and Chemical Corp., 223 W. Erie St., Chicago 10, Ill.*

Mention No. 260 when filling out card.

Scale-of-ten Scaler and Register

New "SC-7, 100" scaler is based on scale-of-ten so that it is possible to read results directly without interpolation. Instrument is provided with a



4-in. high-voltage meter. Coarse control allows a continuously-variable adjustment of Geiger tube voltage from 350 to 2200. Range of fine controls is 0 to 200 v. Power supply percent change in output is less than 0.025 per change in line voltage of 1 percent. Provisions are made for connecting an electrical stopclock so that time required for reception of impulses may be accurately measured. Coincidence loss at high counting rates is determined by dead-time of register.—*Tracerlab Inc., 130 High St., Boston 10, Mass.*

Mention No. 261 when filling out card.

Reset-type Register for Radioactivity Counters

New "Model 1238" electrical-reset register permits a choice of three types of actuation and can be reset automatically with a switch on front panel or from remote contacts. Counting from 1 to 999,999 at up to 12

counts per second is possible. Actuation is obtained with as little as 10 ma. at 50v. Unit operates on 105-125 v, 50-60 cps. and draws 5 watts normal, 30 watts max. during resetting.—*Atomic Instrument Co., 160 Charles St., Boston, Mass.*

Mention No. 262 when filling out card.

Mica-window Counter

New "Mark 1" beta-ray counters, available in two models, are said to have exceptionally long life, with no perceptible change in characteristics

up to four trillion counts. Both models have a threshold of about 1600 v. and a plateau of about 200 v. "Model 3X" has a 1.125-in. window with a thickness of 3 to 4 mg. per sq. cm., while "Model 4X" with a 2-in. window has a thickness of less than 2 mg. per sq. cm. *Radiation Counter Labs., Inc., 1844 W. 21st St., Chicago 8, Ill.*

Mention No. 263 when filling out card.

Radioactivity-type Ore Detector

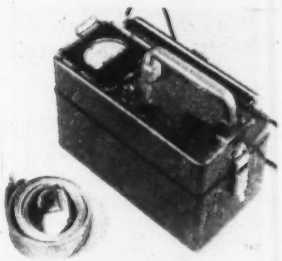
New "SU-7" detector, designed for field use in prospecting for all types of radioactive ores, is unaffected by moisture; will operate after having been submerged in over ten feet of

water. Probe, mounted at end of a flexible 30-in. cable, permits exploration of crevices and small bore holes. Only battery requiring relatively frequent renewal is a standard flashlight cell. Instrument is equipped with earphones and shoulder belt.—*Tracerlab Inc., 130 High St., Boston 10, Mass.*

Mention No. 264 when filling out card.

Radioactivity Survey Meter

New "SU-5" Beta-Gamma Survey Meter is portable, battery-operated and weatherproof; uses a sensitive thin-walled Geiger tube as detecting device, mounted in a detachable probe. Instrument is equipped with two sets of scales, enabling readings to be made



in terms of both milliroentgens per hour in ranges of 0.02, 0.2, 2.0, and 20, or 100, 1000, 10,000 and 100,000 counts per min. A removable probe shield with a wall of 1300 mg. per sq. cm. permits separate measurement of gamma radiation, in presence of beta radiation with energies of up to 2.5 Mev. With probe shield removed, beta rays as low as 0.3 Mev. can be detected by Geiger tube which has a thin wall section of only 30 mg. per sq. cm. Meter drift is less than 0.05 percent per hour and battery life is 240 hours. —*Tracerlab Inc., 130 High St., Boston 10, Mass.*

Mention No. 265 when filling out card.

Cosmic-ray Counters

New line of cosmic-ray counting tubes standardizes on 1 in. dia., and lengths of 12, 20, and 6 in. as respec-

...e preferences of workers in the field. Tubes are argon-ethyl ether filled; employ copper cathodes; operate at 1000 v. Standardization has resulted in a new low price for these tubes.—*Radiation Counter Labs., Inc.*, 1844 W. 21*st St., Chicago* 8, *Ill.*

Mention No. 266 when filling out card.

Radioactivity-hazard Survey Meter

New "Model D-1" radiation-hazard survey meter is an ionization-type battery-operated pistol-grip instrument whose predecessor has been widely used and known as "Cutie Pie." Ion chamber is approximately 600 cc. in volume and is constructed of bakelite tubing. 3 in.-dia. Pliofilm window at

end of chamber has a thickness equivalent to 1 mg. per sq. cm. and is penetrated by beta and gamma radiation of 50 kev or greater. Electronic portions are contained in a cast-aluminum case. Batteries are contained in handle section. Positive internal pressure is maintained by gradual sublimation of a naphthalene moth ball mounted in case and thus avoids usual difficulties encountered in high-humidity operation. Three radiation-intensity ranges of 0-50, 0-500 and 0-5000 milliroentgen per hour are provided. Instrument is accurate to within 10 percent of full scale on all scales.—*Radioactive Products, Inc.*, 3201 *E. Woodbridge St., Detroit* 7, *Mich.*

Mention No. 267 when filling out card.

Radioactivity Count-rate Indicator

New "Type EMA-6" count-rate meter will indicate average number of pulses per unit of time produced by a Geiger-Mueller counter or other suitable detector in presence of nuclear radiations. It operates from 115-v. 60-cps.

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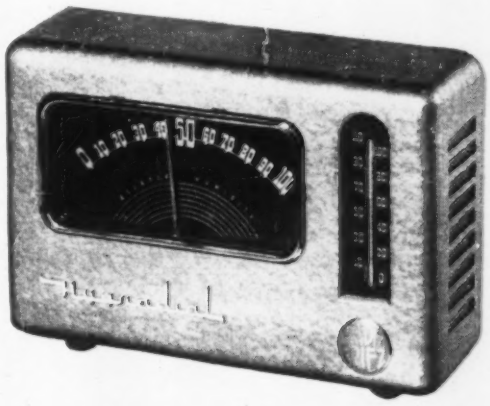
Precision Humidity and Temperature Indicator. Hair-operated and calibrated to professional standards of accuracy by the maker of the world's finest weather instruments. Handsome, modern case—4" high, 5½" wide, 1⅝" deep—desk or wall mounting. A genuine precision indicator, reasonably priced.



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FRIEZ INSTRUMENT DIVISION of Bendix AVIATION CORPORATION

1308 Taylor Avenue, Baltimore 4, Maryland

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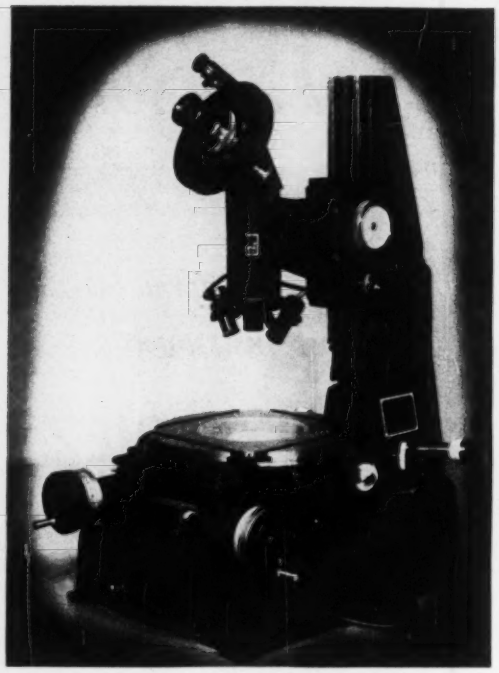
Gaertner

TOOLMAKER MICROSCOPE
with
ROTARY STAGE



Especially useful for checking gear tooth spacings, laying out cam contours, and in performing numerous other precision measurements in either rectangular or polar coordinates.

Stage Rotation	360°
Direct reading to	1 minute
Coordinate Range	4 x 2 inches
Direct reading to	0.0001 inch

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A NEW AIR METER
FOR HIGH-ACCURACY AIR VELOCITY MEASUREMENTS

Read directly from the palm of your hand, Hastings Air Meter registers ranges from 5 to 6,000 fpm . . . weighs only 24 ounces. Powered by 110 volt or portable supply.
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HASTINGS INSTRUMENT CO., INC.
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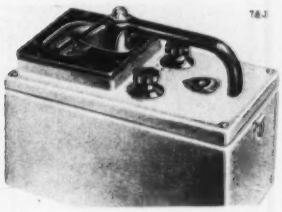
a-c. power line. Indicator is calibrated in units of ten, and displays full-scale counting rates of 10, 100, or 1000 counts. Provision is made for plugging in earphones to provide audible indication of counting rate. Unit is designed for use in conjunction with virtually any known type of radiation detector and includes a high-voltage power-supply system which can be varied over a range of 0 to 2500 v. Equipment measures 13.5 by 6.75 by 9.5 in. overall, and weighs approximately 10 lb.—*Scientific Instrument Sec., RCA Engrg. Products Dept., Radio Corp. of America, Camden, N. J.*

Mention No. 268 when filling out card.

Gamma Survey Indicator

New "Model K-350 Gamma Survey Meter" has a scale-changing instrument with only one range visible at a time. Separate scales for five ranges



are: 0-5, 0-50, 0-500, 0-5,000 and 0-50,000 mr. per hr. Unit is immersion proof and has a 10 percent accuracy over an operating range from -10 to 125 F. Warm-up time is negligible. One-thousand hour batteries furnish power.—*Instrument Div., The Kelley-Koett Mfg. Co., 12 E. 6th St., Covington, Ky.*

Mention No. 269 when filling out card.

Alpha and Beta Counters

New "Models PC-2A and PC-2B" proportional counters for alpha and beta radiation respectively feature low background count rates of one per hour for alpha, and about five per minute for beta radiation. Since no windows

are used, a full 2pi geometry is realized. Maximum sample size is 2.25 in. dia. by 0.5 in. thick. Commercial argon is used for counting chamber. Gas flow control and timing are automatic.—*Nuclear Measurements Corp., 2135 Central Ave., Indianapolis 5, Ind.*

Mention No. 270 when filling out card.

Alpha-particle Counter

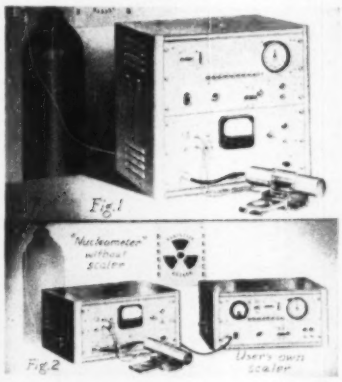
New "Model 501" alpha-counter allows uranium and thorium ores to be quickly, qualitatively, and quantitatively analyzed, when radioactive content is as low as a fraction of one percent. Counter utilizes efficient optical system and phosphor screen to provide a statis-

tical count of alpha-particle scintillations and may be used under subdued white or red light. Unit comes complete with luminescence-quenching filter, radioactive samples, aluminum carrying case, and instructions.—*Clarkstan Corp.*, 11927 *W. Pico Blvd., Los Angeles 64, Calif.*

Mention No. 271 when filling out card.

Radioactivity Indicator

New "RCL Nucleometer, Scaler Type" is a complete instrument (Fig.1) for counting alpha, beta, or gamma radiations with a resolution loss of less than 2 percent at 100,000 counts per minute. Either an internal-type counter with 50 percent geometry or an exter-



nal type counter with an aluminum-foil window of less than 2.5 mg. per sq. cm. are available. Gas supply is regulated and normally lasts 4 to 6 months on one tank. Instrument is also supplied without scaler (see Fig. 2.)—*Radiation Counter Labs., Inc.*, 1844 *W. 21st St., Chicago 8, Ill.*

Mention No. 272 when filling out card.

Gamma-survey Detector

New "Long-probe gamma-survey meter" can be used for monitoring areas in which radioactivity is suspected. A light-sensitive electronic tube is located

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® **POCKETSCOPE**

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Model S-11-A

A "standard" and a "must" wherever a dependable, versatile, portable AC-DC oscilloscope is required for electronic measuring or testing.

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Proudly bearing the heritage of the famed S-11-A POCKETSCOPE, these new instruments include such features as 10-times more sensitivity . . . non-frequency discriminating volume controls . . . trigger sweep . . . and many other important added features. You must see these wonderful new instruments IN ACTION—at the show—to truly appreciate them!

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DIRECT WEIGH is the DIRECT WAY

The New Type 9 Calibrating Stand

- Inherent Accuracy
- Results in Pounds
- Weight and Time are Automatic
- One-Man, Continuous Operation
- Rugged Construction for Portability
- No Temperature Corrections
- No Density, Pressure, Volume or Area Measurements
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. . . to measure rate of flow.

Cox Flowmeter Calibrating Stands utilize a primary method in the Direct Weighing System which is directly sensitive to the two fundamental factors determining rate of flow—weight and time.

Direct Weighing in which weight and time are automatic, has been developed through long experience in the manufacture of stands for calibrating Cox precision fuel flowmeters for the automotive and aircraft industries.

Direct Weighing means outstanding simplicity of operation. It includes many long standing refinements which avoid the errors of ordinary weighing due to manual timing, knife edge and other friction, flexing of hoses, buoyancy of submerged parts, kinetic affects, and other practical factors.

Direct Weighing is combined with uniquely effective flow control, and many other features found necessary to accurate and rapid flowmeter calibration. Instruments in service, including many of the earliest models, have proven to be good investments and continue to pay dividends in reliability and efficiency.

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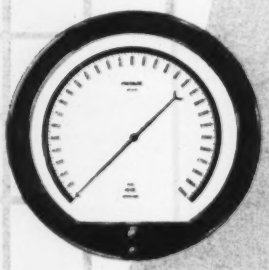

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Heise pressure gauges employ an infinite number of Bourdon tube designs to reduce fibre stress to a point where the gauge can be used continuously at maximum calibration. There is no standard design. Every Heise Bourdon tube is designed for maximum stability and accuracy in a selected range and pressure medium.

Three sizes: 8½ in., 12 in., and 16 in., in ranges from 0-15 to 0-10,000 psi. Prices from $151.60 to $211.20. Write for catalog.

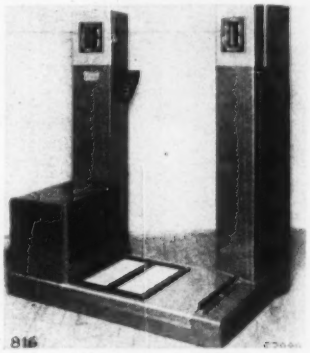
Heise Bourdon Tube Company, Inc.
Newtown, Connecticut

at tip of probe. Attached to tube is a phosphor which gives off light in presence of radioactivity. At other end of instrument, a meter is activated by amplified current from tube to register amount of radiation exciting phosphor four feet away. Instrument is powered by batteries, and carried over operator's shoulder.—*General Engrg. & Consulting Lab., General Electric Corp., Schenectady 5, N. Y.*

Mention No. 273 when filling out card.

Radioactivity Monitor for Workers' Hands and Feet

New "EMA-2B Hand and Foot Monitor" measures simultaneously extent of beta and gamma contamination on hands and feet of those engaged in handling radioactive material, while compensating automatically for background

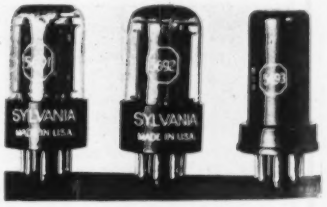


radiation. Subject steps onto foot positions on platform and presses his hands down on base plates in cavities. Plates operate switches which start tubes counting. After a 15- to 90-sec. counting cycle, appropriate green, yellow, or red indicating lamps reveal degree and location of contamination.—*Engineering Products Dep't, RCA Victor Div., Radio Corp. of America, Camden, N. J.*

Mention No. 274 when filling out card.

Industrial Electron Tubes

New "Types 5691, 5692 and 5693" electron tubes suitable for industrial services where dependable operation and a life up to 10,000 hours is required feature ability to resist impact shocks of 100 G for prolonged periods, 500 G for short periods and 2.5 G during continuous vibration at 20 cps,



while being operated at maximum rated voltages. "Type 5691" is a high-mu twin triode for voltage-amplifier use and supplied with series-unit heaters; "5692", a medium-mu twin triode with series-unit heaters suitable for balanced d-c. amplifier, mul-

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ti-vibrator, blocking oscillator and resistance-coupled amplifier applications; and "5693", a sharp cut-off pentode designed particularly for high-gain resistance-coupler amplifier service. "5693" may be operated with number 1 grid-resistance values up to 40 megohms.—*Sylvania Electric Products Inc., 500 Fifth Ave., New York, N. Y.*

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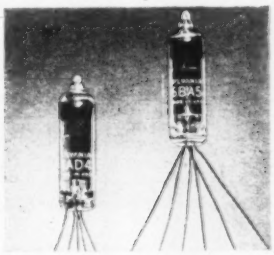
Subminiature Amplifier Tubes

New "Types 6AD4 and 6BA5" triode and pentode subminiature tubes designed for use as Class A a-f. amplifiers or resistance-coupled a-f. amplifiers have a mutual conductance of 2700 and 3300 micromhos respectively. Both tubes are enclosed in T-3 envelopes and are supplied with 6.3-v., 150-ma. heaters.—*Radio Tube Div., Sylvania Electric Products Inc., 500 5th Ave., New York, N. Y.*



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Electropneumatic Timing Relay

New "Bulletin 849" pneumatic timing relay, available for a.c. or d.c., utilizes a synthetic rubber bellows for controlling tripping time. Range is easily adjustable from 10 cycles to 3 minutes, with accuracy of 10 percent. Relay resets instantaneously. Performance is unaffected by temperature, humidity, or vibration. One set of quick-make and -break d-p. contacts is normally open and one set normally closed. A duplicate set of contacts for pilot control can also be provided, actuated directly from solenoid. Unit can be changed from "on-delay" to "off-delay" operation by simply inverting solenoid.—*Allen-Bradley Co., Milwaukee, Wis.*

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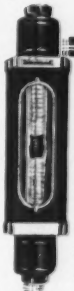

measures & indicates flow rate directly and accurately.

These meters require no straight runs of pipe . . . straightening vanes . . . orifices . . . orifice taps . . . overload protection . . . mercury or other secondary fluid. Pressure loss is low and constant for all flow rates.

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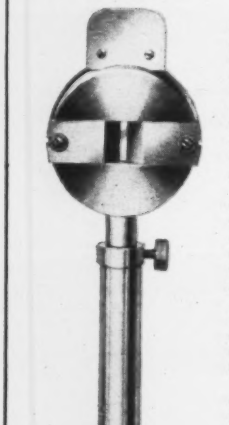
EPLAB

Thermopiles



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*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

CATALYTIC PROCESSES

Continued from page 135

cyclic change of load on the synthetic crude tower and in the rate of production of gas. With this simple arrangement pressure regulation has never been completely steady. On the other hand, a cyclic swing of approximately 2 psig in pressure is of no consequence process-wise.

It will be appreciated that the efficiency of purging of the reactors between regeneration and on-stream periods is extremely important since incomplete purging would obviously present a hazard. Purging of the reactors is accomplished by evacuation with steam jet ejectors. Each reactor is provided with a pressure-vacuum indicating instrument located near the reactor and a pressure-vacuum recording instrument in the control room. The indicating instrument is equipped with a Mercoid switch which is connected to the cycle timer circuit in such a manner that it will cause the

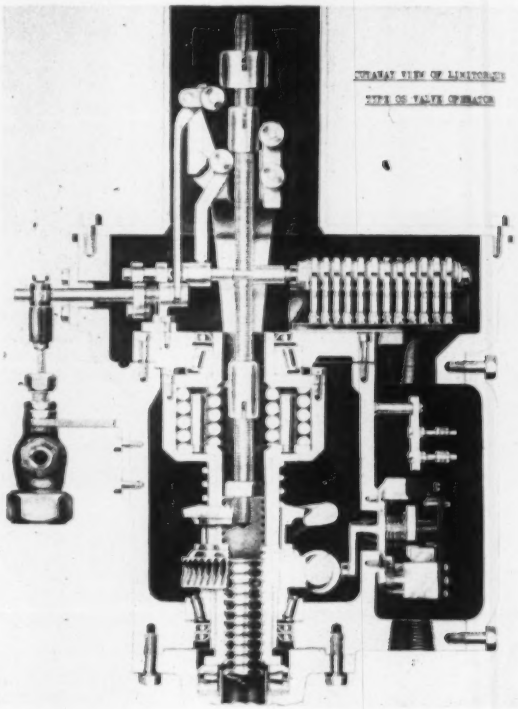


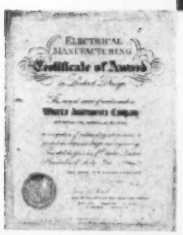
Fig. 8

timer to be stopped if in the allotted purging time the absolute pressure on the reactor is above 10 in. Hg. If the timer stops on such a vacuum test impulse, an audible alarm is given in the control room.

Flow Regulation

The regulation of flow of the oil feed to the reactors and the products from the synthetic crude fractionating tower is conventional in every respect. A relatively constant regeneration air flow rate is assured by the inherent performance characteristics of the turbo-compressor. For survey purposes it often is desirable to know the regeneration air rate and, consequently, flow recorders have been installed in numerous plants. These meters have been actuated by Pitot-tube or orifice-plate differential. Owing to the large sizes of the air lines (many of these lines are 36 in. in diameter) and the general arrangement of the equipment, it has seldom been practical to provide the desired run of straight pipe for the best meter installation. However, since this metering installation is not vital to the control of the process, it has not been considered necessary to improve this set-up.

Likewise, in the regulation of heat transfer salt flow,



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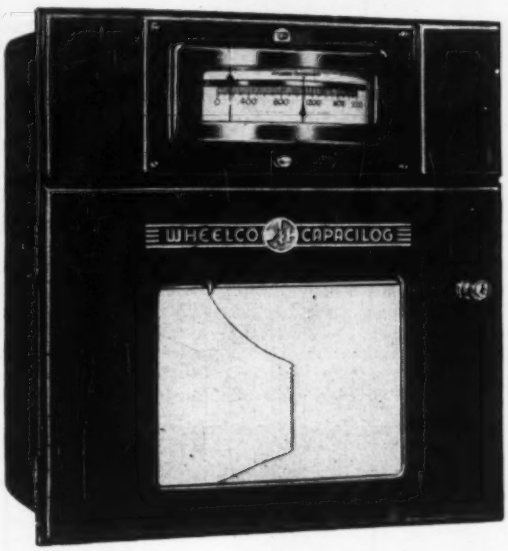

We proudly announce the selection of the Wheelco deflection type Capacilog for a Certificate of Award in the 11th Annual *Electrical Manufacturing* Product Design Awards Competition. In presenting the story of the award-winning design of this temperature recorder to its readers in its October Product Design Number, *Electrical Manufacturing* highlighted these salient features:

"Simplicity in design—achieved by using standard components, complete a-c circuit operation, permanent-mold castings and plug-in subassemblies—combined with a sensitive direct-measuring system produced a lower cost instrument with operating advantages over conventional potentiometer-type recorders."

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special instrumentation has not been required. The design of the salt system includes a geometrical symmetry among the parallel reactors such that uniform distribution of the flowing salt through all parts of all reactors is assured. Each reactor contains about 600 vertical salt cooling tube assemblies arranged in parallel in common tube sheets. Each tube assembly consists of an outer tube and an insert tube. At the top of the insert tube is a fixed orifice for controlling the rate of flow of salt through the tube assembly. Salt enters the bottom of the insert tube, flows upward through the orifice and then by gravity returns down the annular space between the insert and outer tube to the salt outlet zone of the reactor. Early in the development of the design

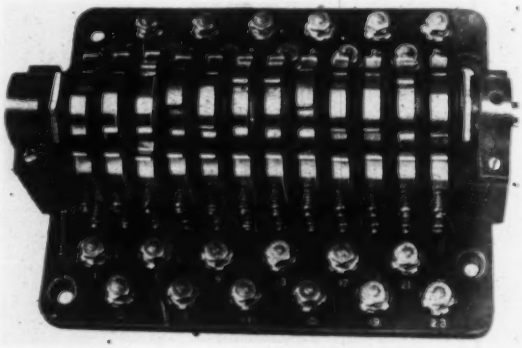


Fig. 9

of this system, it was apparent that steps would have to be taken to prevent vapor binding of individual tubes and consequent lack of uniformity of salt flow through all tubes. The annulus through which the salt returns does not run full and, consequently, the molten salt has a tendency to entrain more or less of the vapors that may be present in the annular section, causing the differential across the controlling orifice to vary in proportion to the extent of the "pumping" action. This effect is, for all practical purposes,

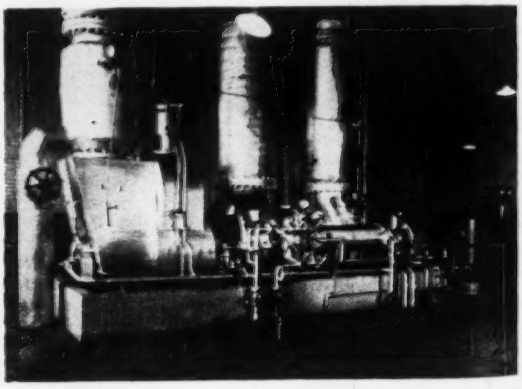
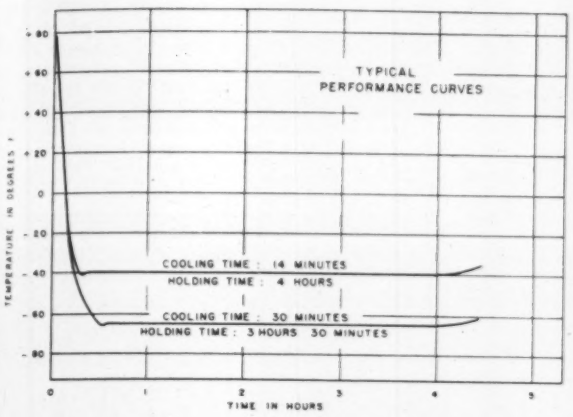


Fig. 10

completely nullified by maintaining a high vacuum on the entire salt return system with small steam jet ejectors. If the absolute pressure on the salt return system is maintained at less than about 5 in. Hg., the mass of vapor in the salt tube annulus is so small that any "pumping" tendency of the salt is negligible and the upstream pressure on the insert orifice is controlling.

Turbo-compressor

The subject of Houdry unit process control would not be complete without a brief word of description of the turbo-compressor equipment which furnishes regeneration air for the process. From process considerations, it is necessary to provide an essentially constant flow of regeneration air re-



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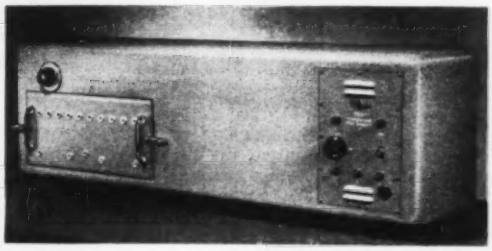
Please request Bulletin No. 5.1.



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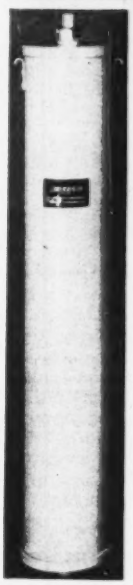

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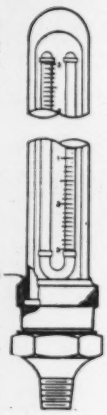

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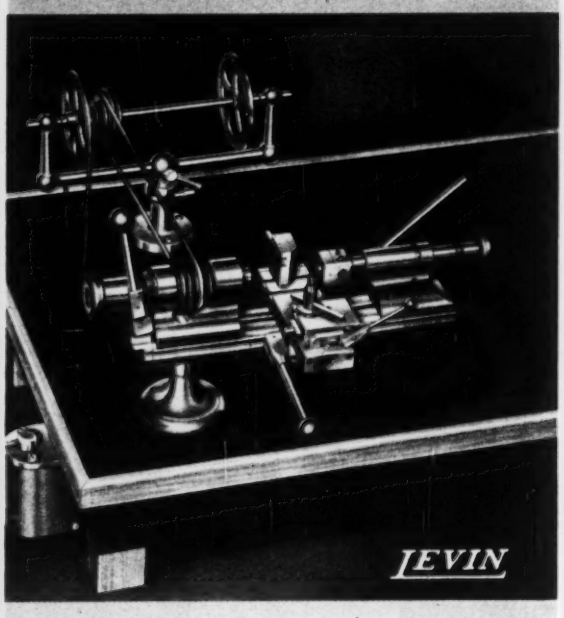

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gardless of pressure drop variations in the system due to fouling of the reactor internals, etc. A multi-stage axial flow air compressor fulfills this requirement. In addition, the process demands that the regeneration be conducted under pressure at about 45 psig. Since a standard Houdry Fixed-Bed unit requires about 40,000 scfm. of regeneration air, it is apparent that the power requirements for air compression are sizable. Consequently, the application of a turbo-compressor assembly was conceived.

Principally, the turbo-compressor machine consists of a hot gas turbine coupled directly to an axial flow air compressor (Figs. 10 and 11). The hot gas turbine is driven

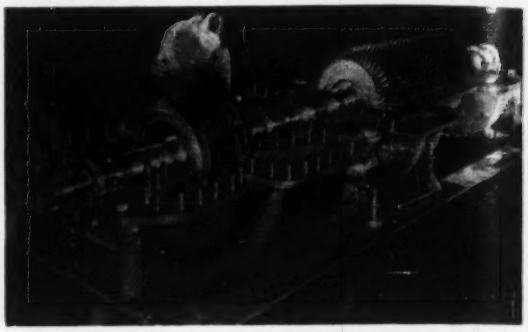

Fig. 11

by the hot regeneration gases returning from the reactors and the power output of the turbine is just about equivalent to the power requirement of the air compressor (Fig. 12). Connected to the compressor shaft through a set of reduction gears are a motor-generator and a starting motor or starting steam turbine. The entire assembly operates at constant speed and in effect the motor-generator is the primary speed regulator inasmuch as it is wired to generate electric power, or supply power to the turbo-compressor assembly by operating as a motor, depending upon whether the power output of the hot gas turbine is greater or less than the power requirement of the compressor. The starting motor or starting turbine is, as the name implies, used to start the turbo-compressor assembly and bring its speed of rotation to the point where direct-fired burners in the air system may be lighted. The firing of the burners is then gradually increased until rated speed is attained and the Houdry unit goes on stream. Thereafter, the heat content of the regeneration fumes supplies most, if not all, of the power required to make the turbo-compressor self-sustaining. Thus, the hot gas turbine-axial compressor machine operating at constant speed fulfills the process requirement of a constant rate of flow of compressed regeneration air and the process itself furnishes the power required for compression.

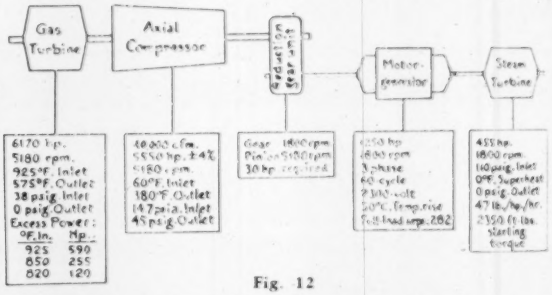

Fig. 12

Spencer's New Book Is Out! *See Page 207*

PROPOSED TENTATIVE STANDARD

AIR PRESSURES FOR PNEUMATIC CONTROLLERS AND TRANSMISSION SYSTEMS

Recorder-Controller Section of
Scientific Apparatus Makers Association

FOREWORD: Recorder-Controller Section of Scientific Apparatus Makers Association Tentative Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining without delay the proper product for his particular need. Existence of a Recorder-Controller Section Tentative Standard does not in any respect preclude any member or non-member from manufacturing and selling products not conforming with the standard.

1—Scope and Purpose

1.1 This standard applies to (a) Pneumatic controllers; (b) Diaphragm motors; (c) Pneumatic intelligence transmission systems.

1.2 The purpose of this standard is to establish (a) A standard air supply pressure (with range) for the three above-named devices, and (b) A standard operating pressure range for diaphragm motors and pneumatic intelligence transmission systems.

2—Definitions

2.1 The following definitions give the meaning of the terms as used in this standard.

2.2 *Pneumatic Controller.* A pneumatic controller is a mechanism which measures the value of a variable quantity or condition and operates to correct or limit deviation of this measured value from a selected reference by pneumatic means.

2.3 *Diaphragm Motor.* A diaphragm motor is a motor used to position a valve or other final control element in response to the action of a pneumatic controller. It consists of a diaphragm to which is attached a push rod, means for elastically loading the diaphragm (such as a spring), and a housing which permits applying air pressure to the diaphragm to oppose the elastic loading. Motion of the push rod is obtained by varying the air pressure on the diaphragm and, within the operating pressure range of the motor, there is a definite rod position for every pressure applied to the diaphragm.

2.4 *Pneumatic Intelligence Transmission System.* A pneumatic intelligence transmission system is a system for indicating, recording or integrating a quantity at a remote point by pneumatic translating means.

Example: A flow measurement is translated into an air pressure at the point of measurement and transmitted by pneumatic means to a remote recorder.

2.5 *Supply Pressure.* Supply pressure is the pressure of the air supplied to the pneumatically operated devices to which this standard applies.

2.6 *Operating Pressure Range.* Operating pressure range is the spread or span between the minimum and maximum air pressures which will position the diaphragm motor or transmission system through its full range of travel.

2.7 *Reset Action.* Reset action is the corrective action of a controller (in conjunction with proportional control) in which there is a continuous linear relation between the deviation of a controlled variable from a selected reference value and the rate of motion of the diaphragm motor or other final control element.

3—Supply Pressure

3.1 The supply pressure shall be not less than 18 nor greater than 20 pounds per squar inch. *Note:* Twenty pounds should not be exceeded due to possible reset action at maximum pressure. The range is one which is practicable to meet with industrial pressure regulators and is sufficiently narrow as to have negligible effect on the performance of the devices to which this standard applies.

4—Operating Pressure Range

4.1 The operating pressure range shall be 3 to 15 pounds per square inch for diaphragm motors and pneumatic intelligence transmission systems.

Note: A minimum of 3 pounds per square inch is desirable when tight seating of the valve is essential or when single-seated valves are used. A maximum of 15 pounds per square inch is desirable for valves and is acceptable for the transmitters and receivers of pneumatic intelligence transmission systems.

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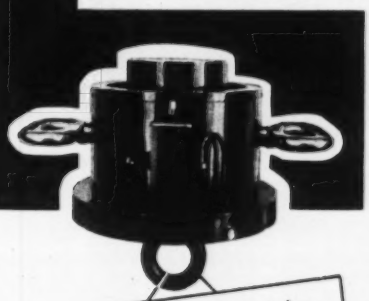

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High Power, Lighter Weight
PORTABLE POWER UNIT

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For high power from a small unit, the new Burgess A. M. Power Units are *unexcelled!* Single cell units scarcely larger than an ordinary flashlight cell deliver currents as high as 100 amperes, at approximately 1.4 volts!

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BECAUSE THERE ARE NO STUFFING BOXES,

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RING BALANCE METERS

The design of Hagan Ring Balance Meters eliminates stuffing boxes—and hence eliminates the troubles that go with them. Adjustment is less delicate, less maintenance is required; there is one less source of friction, hence greater sensitivity; there is no danger of leakage, therefore no way in which the fluid being measured can come in contact with any critical mechanism. No leakage means also that the meter stays in calibration over a much longer period.

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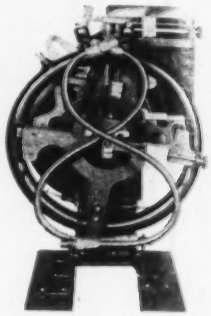
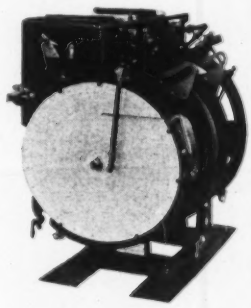
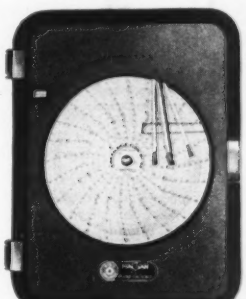


Back view of single ring, high differential meter, showing S-tube connection.



Front view of dual meter with one high differential and one low differential ring.



Front view of three-pen meter in case. Panel space is the same for all models.

JOURNAL of the Instrument Society of America

I.S.A. National Office, 921 Ridge Ave., Pittsburgh 12, Penna.

Vol. 6 **FEBRUARY 1950** No. 2

Program Chairmen Note!

Stumped for a program? Then write to the National Office and borrow a one-half hour or a full hour of color and sound and let your members visit the 1949 Instrument Exhibit. The new slide film with accompanying sound, as described in the December ISA Journal is now ready. Film No. 1, running time 30 minutes, describing the new instruments exhibited by 18 exhibiting companies begins this "Tour" of the 1949 Instrument Exhibit. Film No. 2, 30 minutes, 19 companies; and Film No. 3, 30 minutes and covering 12 companies, complete the tour.

Give us the date of your meeting and indicate the film you wish, and slides and sound tape will be sent you together with complete instructions for putting over a smooth running, eye filling, highly instructive and most interesting program or supplementary program. Schedule a film before your regular meeting. You will need a 2 by 2 in. slide projector and a Brush recorder.

The following companies are covered:

Film No. 1 includes: Aircraft Marine Products, Inc.; Automatic Electric Sales Corp.; Barton Instrument Co.; Bristol Co.; Buffalo Meter Co.; Century Geophysical Corp.; Climax Engineering Co., Controls Division; Consolidated Engineering Corp.; R. W. Cramer Co.; Davis Emergency Equipment Co.; Engineers Specialties Division, Universal Engraving & Colorplate Co., Inc.; Claud S. Gordon Co.; Gormac Products, Inc.; Gow-Mac Instrument Co.; Hammel Dahl Co.; Helicoid Gage Div.; American Chain and Cable Co.; Instruments Publishing Co.; and Leslie Co.

Film No. 2 includes: Leeds and Northrup Co.; Magnetrol, Inc.; Manning, Maxwell and Moore, Inc.; McAlear Manufacturing Co.; Milton Roy Co.; Mine Safety Appliances Co.; Penn Industrial Instruments Corp.; Photoswitch, Inc.; Precision Thermometer and Instrument Co.; Precision Tube Co.; J. F. Pritchard and Co.; Pyrometer Instrument Co.; Specialty Battery Co.; Standard Electric Time Co.; Taylor Instrument Co.; Vapor Recovery Systems Co.; W. M. Welch Scientific Co.; Wheelco Instruments Co.; and Yarnall Waring Co.

Film No. 3 includes: American Meter Co.; Annin Co.; Bailey Meter Co.; Arnold O. Beckman, Inc.; Brooks Rotameter Co.; General Electric Co.; Heiland Research Corp.; Illinois Testing Laboratories, Inc.; Nash Engineering Corp.; North American Phillips Co.; Panellit, Inc.; and Trinity Equipment Corp.

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Continued on page 187

Local Section Publications of the ISA

Five local Sections of the ISA have made their voices heard in the cities and districts they serve by publishing Section magazines which reach out to tell the story of instrumentation and ISA activity to a wide public of members and non-members alike.

As a rule each of the magazines reviewed below grew from a one-sheet meeting announcement to the worthwhile publication it is today. In all there are tell-tale indications that no small amounts of energy and ingenuity went into their production.

The magazines perform a service to Section members in that they announce Section activities and provide a locus for the exchange of technical information and a medium for cheerful sociability. In short, they clarify the meaning of "The Section" to members. They strengthen Section cohesion by welding friendships, by encouraging active participation in programs, by promoting membership in the Section and by bringing in new members.

Most important is that the magazines described below help broadcast to a large public the part that instrumentation plays in the industrial and economic world.

They have become an integral drive shaft of Section activity.

* * *

The ISA Chicago Section Events

The Chicago Section publication, the *ISA Chicago Section Events*, is a 5.5 by 8.5-in. printed magazine issued in either 8- or 12-page editions. This colorful pamphlet is printed in red, green, brown, blue or purple, or shades of these, and appears in a different color on successive months. It is issued monthly except during June, July and August. Present circulation is 1,500.

The magazine has been published under its present title since the Section received its charter in 1946. Essentially the same format has been used since 1941, when it originally appeared as the *Chicago Society of Measurement and Control Events*.

HASELTINE

A prominent white oval on the front cover announces on first sight the who, what, when and where of the next Section meeting. A one-eighth-inch white border sets off the cover.

On the first inside right-hand page, which is topped by a masthead, appear the repetitive lists of Section Officers, Executive Committee, Standing Committee Chairmen, *Events* Staff and members on Technical Sub-Committees.

The *Events* staff at present consists of 7 men—one editor, five news editors and one advertising editor. Present editor is O. M. Haseltine, of the Revere Corporation of America.

Advertisements are sold in one-half page units, and kept to a minimum of eight half pages and a maximum of 11 pages per issue.

In the 8-page issues of the magazine the center, left and right-hand pages are occasionally devoted to full page announcements of the next two coming meetings. A rather complete speaker's biography and subject abstract accompany these notices.

Frequently there appears a "Tentative Meeting Program," a one-half page insert, listing, in form suitable for clipping, the complete data on meetings from two to six months in advance.

A business reply card for dinner reservations is glued or inserted loose into issues.

Departments of the magazine which appear from time to time are "Recordings" and "National Events." "Recordings" welcomes new members, reports on those changing jobs, receiving promotions, transferring locations, etc.

A Section membership list is published several times throughout the year.

"National Events" has reported on such activities as the National Employment Service and Register, the Recommended Practices Committee, has given notice of the Annual Business Meeting, and has explained membership requirements.

A series of four full-page articles on the entire scope of the ISA appeared in the early 1949 issues.

Other articles announced new Section Officers, reported on the formation of the Nominating Committee, and reviewed past Section meetings.

The report of the Chicago Section Director, R. R. Proctor (Pure Oil Research & Development Lab.), on the Annual Board of Director's Meeting appeared in the November issue.

The Aruba Bulletin

The Aruba Section *Bulletin* is a mimeographed, black and white booklet composed of approximately 8½ by 11-in. sheets double stapled on the left edge. News items appear on the right hand pages of the magazine—the left hand pages remain blank or carry full page sketched advertisements.

Since the *Bulletin* first appeared in 1947 as a one page meeting announcement, it has grown in size and circulation. It is published monthly under the close supervision of a staff of 15 who meet regularly before each issue. Present Editor is Burnell W. Furstenau, graduate of the University of Nebraska with a BS in Mechanical Engineering.

FURSTENAU

The *Bulletin* Art Director, John De Lange, is to be complimented for the regular, decorative cover sheet. The cover, occasionally appearing in color, points up the talk given at the last Section Meeting, or pictorially emphasizes National events.

The second page of the *Bulletin* serves as a relatively static introductory page. Here are listed the Section Officers and the Bulletin staff members. A paragraph on the Aims and Purposes of the *Bulletin* appears regularly.

An interesting Editor's Corner carries last minute news items and expresses general comments.

An editorial usually appears on the third page. Guest editorials are welcomed. Several National ISA Presidents have contributed writings. Inspirational articles that encourage good fellowship and promote Section activity, as well as material of special Sectional interest appear here.

A complete Section membership list is published four times a year. New members are welcomed as they join the Section.

Approximately four full-page, mimeographed advertisements appear in each issue. Contracts are on a yearly basis. Preprinted 8.5 by 11 in. advertising insert sheets, supplied by the advertisers, are stapled into the *Bulletin* as occasion demands.

The remaining pages of the *Bulletin* are devoted to articles of Sectional, National, and technical interest. Section meeting announcements, with biography of speaker and abstract of subject, run to about 75 percent of a page. Personal news of Section members, new jobs, new instrument problems, and new achievements in their work are given space.

Humor is not left out. Quips appear in odd spaces. A novel idea was used in the December 1949 issue—a crossword puzzle designed for instrument men.

The *Bulletin* seems to be shaped by the editorial policy expressed in the following quote from a letter by Jim Lopez, Business Manager of the *Bulletin*, "These publications are the only means that quite a few non-members have of knowing about our activities."

The ISA Frontier Transmitter

The ISA Frontier Transmitter is the publication of the Niagara Frontier Section. It is another 5.5 by 8.5-inch printed pamphlet appearing in 8- or 12-page editions, and issued in different colors on successive months.

LAWRENCE

The *Transmitter* is published every other month under the editorial direction of O. R. Lawrence of the Vincent J. Brown Company. The January 1950 copy is Volume 2. A relatively young Section magazine, it first appeared in 1948 as a 4-page meeting announcement carrying a page and one half of advertisements. Ads presently run to about four pages per issue.

A distinctive feature is its bleed cover. Like the *Events* and the *Headlines*, essential information on the next Section meeting is displayed prominently on the front cover. Masthead, list of Section officers and committee chairmen regularly fill page 2. A full page is usually devoted to the meeting announcement, with an occasional half-page of information about the speaker. Membership rosters and new members lists appear regularly.

The January 1950 issue contained a three-quarter-page article on "Instrumentation—Small Industry, Large Role" by G. E. Bailey. The same issue carried a complete breakdown of Society membership by Section and grade, with totals. A list showing ISA growth of membership appeared here also. A calendar of ISA Section Secretaries with data on programs, meeting times and places, similar to the one appearing in the ISA Journal, has been printed.

Pittsburgh Headlines

The Pittsburgh Section *Headlines*, with a present circulation of 1800, published since 1944, and appearing monthly September through May, is a 6 by 9-inch printed pamphlet issued in 8-, 12-, 16- or 20-page editions. Advertising occupies about one-third of the total space.

Present Editor is W. C. Adams (Gulf Research & Development Company), W. K. Bowman (Gulf Research & Development Company) is Advertising Manager. An editorial panel of seven and a reportorial staff of nine assist in publishing the magazine.

ADAMS

In addition to the lists of Section officers, Committee chairmen, new members, and membership rosters regularly published, news is channelled into several well-established departments. "Headlines Official" concerns itself with news of National importance directly affecting the Section, activities of the Section Executive Committee, or news of significance to the member as a member.

"Headlines Strictly Personal" or sometimes called "Headlines Local" contains informal news of a personal nature on Section members.

Headlines is unique among ISA magazines in that it publishes cartoons and illustrations. Humorous couplets and jokes are included occasionally.

"Panhandle Parade," usually running to three-fourths of a page and appearing irregularly, is a bit of editorializing, wit, and personal news which gives voice to a group of Section members who live in the panhandle area of West Virginia. A correspondent contributes the material for this interesting feature.

Since February 1949, *Headlines* has been doing a dual job in announcing and reporting both the meetings of the Pittsburgh Section Inspection and Gaging Sub-division as well as its own programs in industrial instrumentation. These notices usually require two full pages per issue.

Definite attempts have been made to make *Headlines* a medium for Technical discussion. A question department, to "stump the Section experts" was originated—a provocative question is printed and the members are asked to send in their answers.

Meeting reports are done in some detail, adding to their technical value. A series of follow-up articles reporting on each of the plant inspection trips made during a regional meeting made interesting and instructive reading. Guest editorials appear from time to time, as well as articles contributed by members.

Many short articles and news items appear throughout the magazine which tell of developments taking place in the Pittsburgh area of interest to the instrument man—new departments, methods or instruments set up in district plants or laboratories; allied activities of other Societies in the area; new developments occurring in district instrument education centers, etc.

The Detroit Recorder

The *Detroit Recorder* has been published ten times a year, from September to June, since 1945. It has a circulation of 1,000, is issued in 8- or 12-page editions, measures 5.5 by 8.5 inches and is printed in black with occasional red.

Page 2 contains the masthead, list of *Recorder* Staff, and list of Section Officers. An editorial frequently appears on this page, although a list of Section Committee Chairmen and a meeting notice have been placed here.

Advertisements run to approximately four pages per issue. Present staff is Walter G. Moline, Editor, and M. W. Weber, Advertising Manager.

Some of the articles published within the last year included regularly appearing reviews of past meetings, and future meeting notices; periodically published Section membership rosters and lists of new members; and an occasional announcement of a job opening or a situation wanted. Biographical data on prominent speakers and news of recent achievements of Section members have appeared.

MOLINE

A report on a plant trip and on the National Spring Meeting were published. A two-page article on "Instrumentation of a Refrigeration Laboratory" by W. E. Wilson (Nash—Kelvinater Corp.), appeared in the June 1949 edition.

The most outstanding characteristic to be noted about the *Recorder* is the frequency and value of the forceful editorials found in its pages. Approximately six and one-third pages of editorial writing appeared in nine issues examined. Editorials by past-editor and Section president J. W. Head were entitled "Our Responsibility" and "Instrumentation."

The editorial "We Want Blood" by W. G. Moline, which appeared in the September *Recorder*, was republished in the November ISA Journal. "Let George Do It" by Victor G. Raviolo appeared in the May *Recorder* and was also republished in the Journal. Another example of this type of inspirational needling appeared in the October *Recorder* under the title "We Grow," the last line of which is: "Our Goal this year should be and must be to grow along with the Parent Body. It will take work, sweat and blood. We can't stand Still, we either go up a little or all the way down. It's up to each and every member of this Section to decide which way we go. If you don't care, sit tight; but if you do care, and we think you do, push fellow, push."

Walter G. Moline, in a "Letter From The Editor," which appeared in the November issue, stated the *Recorder* editorial policy this way: "To be fundamental, the *Recorder* is supposed to let the outside know what Instrumenticians do with Instruments here in Detroit."

Intrumentation For Exterior Ballistic Research In Rocketry *

By L. M. BIBERMAN†

WITH each major industrial development comes the need for a system of measurement or control instrumentation. Such indeed was the case with the development of American Rocketry. First the problems were concerned with getting some rocket projectiles that could be used. Later, however, the need for more accurate sighting tables and better general accuracy made necessary finer manufacturing controls and more information on flight behavior.

Probably the most important single instrument for such research was the Bowen acceleration camera, followed closely by the German Askania Theodolite modified here to permit even more versatile performance. The N.O.T.S. modification of this theodolite has eliminated all mechanical bearing scale shutters, substituting instead radio controlled discharge lamps to permit dial synchronization to within perhaps ten to twenty microseconds.

Even the venerable, versatile Bowen camera has been redesigned for better and more precise data recording.

Both these instruments, however, rely upon data recorded at a distance. In some cases, the distances involved are several miles. Even the very finest telephoto optics cannot prevent severe distortions caused by atmospheric refractive troubles such as "boilings" as the ground begins to warm. This data obtained at a distance becomes subject to limitations of resolution dependent upon atmospheric conditions, image size, tracking rates and instrument vibration which, although small for large angles, can be surprisingly large for small angular measurements at long distances.

The second main source of aeroballistic data is obtained from wind tunnels which are highly developed and capable of operations in supersonic as well as in the subsonic range. No tunnels, however, appear to be very satisfactory in the transsonic region.

The third source of data is obtained by sensitive instruments placed within the projectile and which telemeter the data via a radio link. There are inherent sensitivity and linearity limitations to this technique also.

The fourth technique, but little known, is the solar yaw camera shown in the following photographs. The camera, located within a spin-stabilized projectile, photographs the sun once during each revolution and permits assessment of the resultant record to approximately 0.03 degree. A typical record is shown. This newly engineered camera (based on W. R. Smyth's solar yaw camera) has been steadily used at N.O.T.S. to yield better than 95 percent data on all firings in the past few years. Spin rates must also be known, for such data to be effective as must velocity, deceleration, etc. Thus, a large additional instrumentation array is required for a precise determination. Such procedures are complex, costly, and difficult in assessment. It is not surprising, therefore, that thought was given to creating a precise indoor range where extraneous winds would not enter and temperatures were known; where data could be recorded by photographic instruments scattered closely along the flight path.

It had been the contention of other laboratories over a long period of time that certain basic coefficients relating to the aerodynamic behavior of bodies in flight might be best measured at close range by precise photographic techniques. Two of these quantities—the normal force and the center of pressure—seem to lend themselves best to such a technique. For this reason, the

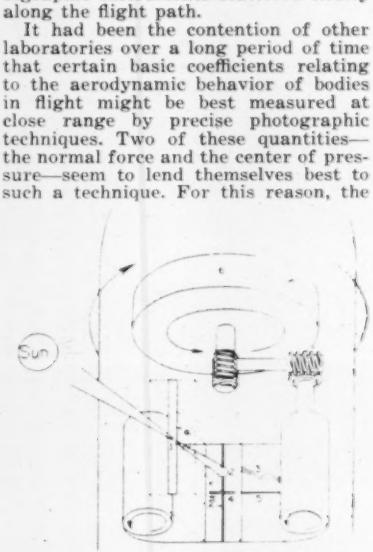

Fig. 1. Schematic diagram of yaw camera shows: 1. Pinhole; 2. Image of solar disk; 3. Successive exposures on film; 4. Cross slit; 5. Exposure through cross slit (by sky light) forming base line; 6. Flywheel.

military establishment has investigated the technique in the so-called enclosed range. It appears that the two quantities named can be determined more precisely in such a facility at small angles of attack than by present wind tunnel techniques.

The problems of such measurements, however, are not simple and have been met heretofore primarily through the use of the "spark range" with all of its inherent limitations. Although one of these limitations may possibly be overcome shortly, the spark range presently offers the researcher but one pair of normal (i.e. right-angle) images giving the three sets of coordinates at each spark station. To cover adequately a reasonable trajectory with images spaced closely enough to allow study of a single nutation of a projectile would require a very large number of spark instruments and an elaborate control system.

In order to somewhat simplify the problems of direct exposure (without aid of lenses) on film, the shadowgraph technique has been used whereby a shadow created by the spark source is photographed by a suitable camera. Once again, the technique is usually restricted to one image pair at each spark station.

In order to remove the limitation imposed by spark techniques and to permit a greater degree of precision in measurement, a new type silhouette photographic procedure has been developed, permitting the study of relatively large projectiles over intervals in which projectile images may be obtained closely together over a trajectory of approximately 450 feet.

This new technique was made possible by:

a. High speed stroboscopic lighting
b. Low cost reflex reflectors,
c. A special wide field camera.

As visualized in the very early stages of design, the problem appeared to rest almost entirely in the design of lighting circuitry to permit the rapid flashing of high intensity sources of but one microsecond flash duration. From studies made of existing sources the spark gap was ruled out and the Edgerton-General Electric FT-125 gas discharge tube adopted. In order to obtain sufficient light for direct photography of typical projectiles under study, it was necessary to operate the lamps far above the nominal voltage ratings or to sacrifice the required brief flash duration. Broadly speaking the amount of light during a flash is governed by the product of the lamp resistance (during discharge) and the capacitance from which energy is fed to the lamp. The effect of capacitance upon flash duration in the region of interest for a typical flashlamp studied is tabulated below. The photographic intensity of the lamps as measured by reflection from a grey scale is also tabulated.

Capacity of dFD	*Flash Duration Microseconds*	*Relative Light Intensity*
.025	1.1	1.2
.04	1.3	2.5
.05	1.4	2.8
.10	1.7	6.2

The efficiency of the lamps in this region is approximately seven lumen-seconds per joule. The peak intensity is

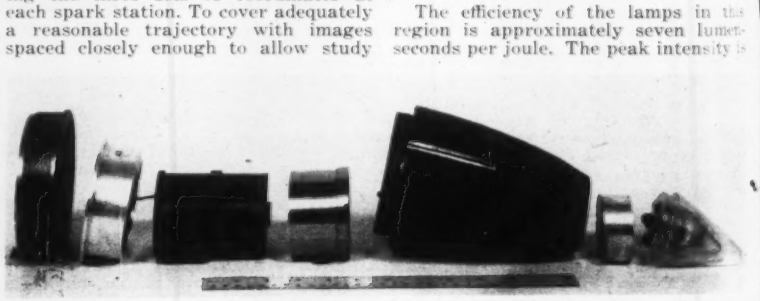

Fig. 2. 35-mm. Solar Yaw Camera Rocket Head stripped to major components.

* Presented at the Fourth Annual Conference of the Instrument Society of America, Sept. 12-16, 1949, St. Louis, Mo.

† Research Dep't, U. S. Naval Ordnance Test Station, Inyokern, Calif.

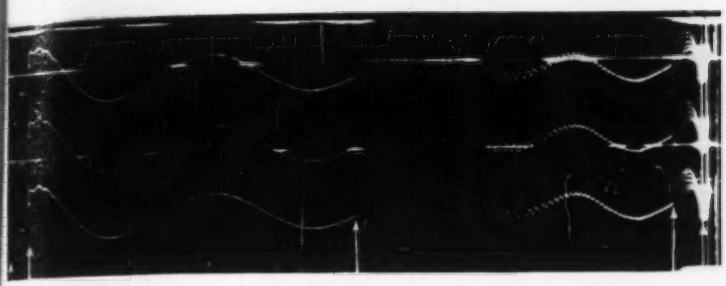

Fig. 3. White arrows at bottom indicate (from left to right) start of record, stoppage of film, first impact (center), second impact, third impact.

estimated to be approximately 2.5 x 10^7 lumens.

Thus, to photograph projectiles effectively it is required that the lighting equipment be pulsed in such a manner that several lamps could be discharged simultaneously to provide the required illumination. The problem of simultaneous flashing of multiple banks appeared to be more of a problem than actually developed. In present circuitry the use of multiple lamps appears to increase the over-all flash duration by less than approximately 0.2 microseconds.

Thus, it appeared the problem was solved and it should be merely necessary to distribute a proper number of lamps and pulse them at proper intervals to get the required photographic results. Unfortunately, this was not the case.

With the lighting problem well in hand a series of preliminary photographs were taken with most disappointing results. It was realized, of course, that photographing highly polished (40 microinch finish) projectiles would offer some difficulty and, therefore, we were prepared to utilize multi-source illumination to highlight the edges and make possible a sharp image of such projectile edges. We then attempted photographing the projectiles utilizing highly diffuse illumination. This latter means was attempted through almost every type of diffusion technique we could turn to our purpose. In almost all cases, the results were the same. A photographic image was obtained in which some contour line appeared as the edge. These contour lines would have permitted accurate determination of the center of gravity of the projectile, (since true edges are not necessary for this) providing the projectile passed through a zone of uniform, symmetrical illumination. This would not be the case except in a few, very rare instances. The net result was an image in which contour lines at different projected radii appeared as the edges of the projectile. This was caused by a projectile receiving more intense illumination on one side than the other due to the relative distances between the projectile edges and two diametrically opposed lamps. For cylindrical bodies with no yaw, the true position could be calculated from the apparent position if all parameters were known. For a yawing ogive this would be a difficult determination indeed. Thus, distorted images were the rule with projectiles apparently changing shape and losing symmetry as one moved the lights relative to the subject or camera.

Backlighting techniques were tried, but since two cameras with axes intersecting at 90 degrees at the ideal trajectory are used, true backlighting could not be used since a displacement of the projectile from the ideal trajectory line would expose one camera to direct illumination by one of the lamps. Thus, each backlighting fixture was displaced so that no direct ray could enter a camera lens. This technique again was subject to the same difficulties of contour lines appearing as false edges dependent upon the relative position of the projectile to the two backlighting fixtures. Thus no significant gain had been made.

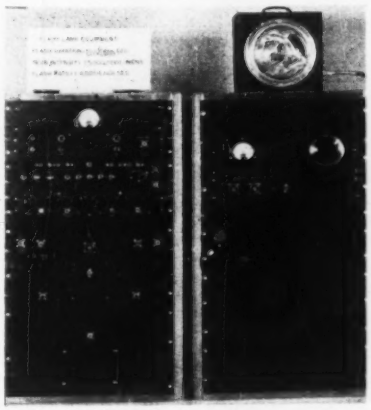

Fig. 4. Multiple-flash equipment. At left are two resonant-charge and discharge circuits and control circuit; at right, 10,000-volt power supply with 12 microfarad energy-storage capacitor bank.

At this point, it became apparent that the entire undertaking was dependent upon developing a suitable illumination system.

Fortunately, this was finally rather easily solved through the use of a reflex-reflector system and silhouette photography.

Attempts were then made to use Minnesota Mining and Manufacturing Company "Scotchlite" reflex-reflector material as background. This was a most fortunate choice. The principle involved is indirect silhouette, not shadowgraph techniques although the two may appear as similar techniques at first consideration.

In this silhouette technique, the lamps are directed toward a reflex-reflector screen having the properties of returning the greater portion of reflected light back to its source in the same manner as the usual corner reflector. Thus to get a reasonable amount of light into the camera, it is necessary that the lamps be mounted within a few inches of the front nodal point of the camera.

The wide-angle "Scotchlite" reflector used has a reflection coefficient that decreases on either side of a normal ray. Thus, in order to obtain uniform background density on the photographic plate, it is necessary to illuminate the Scotchlite in such a manner that the light intensity on the screen varies inversely with the reflective characteristics of the reflector and the transmission characteristics of the camera lens. This has been achieved most successfully by using three lamps directed to cover the three zones of the reflector; right, center and left. The right and left zones are more highly illuminated through the use of increased capacitance across the discharge lamp while the more reflective center section needs but comparatively little light. The use of the reflector system has so drastically reduced the required amount of light that no appreciable variation in light duration is caused by the variation in capacity across each lamp.

The net result is a background brilliantly illuminated periodically for durations in the order of one microsecond. The projectile passing before this reflector is photographed in silhouette. In some rare cases, a shadow also appears on the background screen but there is no doubt about which is silhouette and which is shadow. The depth of field is such that the projectile appears as a sharp image within its anticipated zone of dispersion. The reflex-reflector is well beyond this zone (primarily to prevent aerodynamic interference) and thus the shadow, when it does appear, is a fuzzy image.

It will be seen that with a projectile passing such a reflector, which is illuminated, say half a dozen times while in the field of view of a single camera, each silhouette produced tends to be obscured by the light from the reflector that previously was blocked by the presence of the projectile. Thus the number of images obtainable (and therefore flashes to be used) are dependent upon such factors as the density and minimum density ratio of the silhouette and the background that will permit assessment to the required degree of precision.

With the technique of the reflex-reflector, the use of not more than seven images per plate, a camera to trajectory distance of twenty feet and a lamp

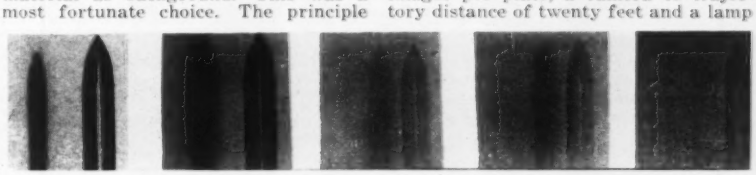

Fig. 5. Multiple-flash silhouette photographs. Ratios (left to right—1:0, 2:1, 4:3, 6:5, and 12:11) are those of total flashes to flashes superimposed upon silhouette; light intensity adjusted so that background intensity was the same in each case.

to reflex-reflector distance of thirty feet, it is possible to determine a projectile edge to within three to four microns on the photographic plate. This is approximately twice the anticipated precision for such a system.

The illumination problem, therefore, except for minor details is considered solved.

The final problems were the design of the camera and the building to house the installation.

The camera was designed on a full kinematic support permitting leveling independent of azimuthal or elevation adjustments. The front nodal point is so located that the camera may be rotated either in elevation or azimuth without shifting the front nodal point. The lens assembly is housed so that the rear nodal point to plate distance is constant over the range of operating temperatures as long as steady state conditions prevail. There is no significant change in focal length with temperature over the limits involved. All camera castings are Meehanite, carefully heat-treated for maximum dimensional stability. Fiducial mark projectors are built in the camera to project a 0.001-inch spot (within a locating circle of larger size) on the horizontal (long) axis of the 4 by 10 inch plate. The lens used is the Goertz Aerotar of 6-inch focal length mounted in a special barrel.

The laboratory building presently used is a 40 by 100-ft. Butler building. The final laboratory design is not yet complete. It will be 480 ft. long, 40 ft. wide and about 30 ft. high. The cabling terminates in a control room located alongside the laboratory proper. Into this control room come approximately 800 control leads and 150 coaxial cables. The 100 kw. 10 kv. power supply is located in a basement below the control room. Most of the surge on the feeder lines is prevented by u[illegible] of a 10 kv. 500 microfarad capacito[illegible] on the output of the rectifier. An ad[illegible]tiona[illegible] 75 kw. is required to operate fi[illegible]ments and many smaller control un[illegible]s and power supplies located at each [illegible]amera station.

It is anticipated that the fina[illegible] facility will be ready for initial ch[illegible]ck-out by January 1, 1951.

ACKNOWLEDGEMENTS

The research and development in the fields of circuitry for microsecond light sources and the illumination techniques used therewith have been carried out by Mr. E. C. Barkofsky, assisted by Mr. Edwin P. Martz, Jr., Mr. R. C. Hopkins, Mr. Carlton Johnson, and Mr. Clyde McCrary. The development of the precision wide-angle camera was accomplished primarily by Mr. J. R. Watson, assisted by Mr. Allan Auchterlonie, Mr. Wallace Allan, and Mr. Eugene Roth.

Inspection And Gaging Facilities In The U.S.A.*

By ROGER L. GEER†

THE past year has been marked by considerable confusion in many fields of Industrial activity. It has been a frequent occurrence to have people from both local and distant shops inquire about precision measurement services.

A remarkable aspect of recent months behavior is the unearthing of exceptionally fine equipment, manned by competent technical personnel, nearby the origin of the service sought. This has led me to investigate this matter with the view of assisting the cause, without lengthy searching each time an inquiry is received. I am convinced that many do not realize the scope of our present, established, gaging organizations.

In trying to list and evaluate all the laboratories, shops, and departments that can accomodate measurement problems, no complete cataloging has been attempted. We do have a card file set up at Cornell in which we have listed the services available in each type of inspection and gaging technique. This list is by no means complete as yet. Anyone is welcome to write us—a penny post card will be just as earnest an inquiry as an air mail letter—and we will do our best to provide information as to where the particular service should be available.

Now this may sound very adolescent, since most people are aware of certain well-established units for carrying on this type of work, but few seem to realize the scope of such units. Certainly we should get as direct a solution as possible—NEARBY!

If you are not in close touch with your local organizations via the technical or service clubs, the telephone book in your locality has a classified section. Beyond that, the local library —or possibly your own Purchasing department—has a copy of Thomas' Register. In this latter tome are listed some 3,000 advertisements for the many types of precision measurement equipment. This includes some twenty-five shops specializing in gage rebuilding and repair.

Aside from the bona-fide commercial agencies for inspection apparatus, there are at least three other groups with laboratory facilities for precision measurement. These all have, in addition to apparatus, qualified staff for consultation and possible research.

About July of 1945 all thirteen Districts of the Ordnance Section of the U. S. Army made contracts with various Universities throughout this country, establishing "stand-by gage laboratories." There were originally twenty-eight set up, but circumstances have decreased the number to about twenty-five active units. A list of these follows:

University Gage Labs In Ordnance Districts

School	Location	Lab. Director
*Agri. & Mechanical College of Texas	College Sta., Texas	C. W. Crawford.
Brown Univ.	Providence, R. I.	P. N. Kistler.
*Case Institute of Technology	Cleveland, Ohio	E. J. R. Hudec.
*Cornell Univ.	Ithaca, N. Y.	R. L. Geer.
*Ga. School of Technology	Atlanta, Ga.	H. S. Weber.
*Lehigh Univ.	Bethlehem, Pa.	J. M. Beauchamp.
*Mass. Institute of Technology	Cambridge, Mass.	P. A. Smith.
New York Univ.	New York, N. Y.	W. A. MacCrehan.
*Penn. State College	State College, Pa.	W. H. Armstrong.
Rice Institute	Houston, Texas	J. R. Dogget, Jr.
*Rochester Inst. of Technology	Rochester, N. Y.	F. O. Fuhrman.
*Rutgers Univ.	New Brunswick, N. J.	U. C. Holland.
*So. Methodist Univ.	Dallas, Texas	C. H. Shumaker.
*Stanford Univ.	Palo Alto, Calif.	S. C. Ashton.
*Univ. of Buffalo	Buffalo, N. Y.	F. H. Thomas
*Univ. of Cincinnati	Cincinnati, Ohio	Walter Soller.
Univ. of Connecticut	Storrs, Conn.	E. R. Stephan.
*Univ. of Michigan	Ann Arbor, Mich.	O. W. Boston.
*Univ. of Rochester	Rochester, N. Y.	Donald Street.
Univ. of Syracuse	Syracuse, N. Y.	John Barron.
Univ. of Wisconsin	Madison, Wisconsin	J. W. McMaul.
*W. Virginia Univ.	Morgantown, W. Va.	R. P. Davis.

*Colleges offering gage laboratory courses. Courses also offered at Alabama Polytechnic Institute, Michigan State University, and University of Florida. (From survey made for *American Machinist* magazine by Mr. Tangerman in the April 7, 1949 issue.)

You will find these units quite completely equipped in most instances and eager to assist in outside activity. By "outside assistance" I mean service in addition to that required at the school for technical instruction and the uses for their own shops.

There are other Universities and Technical Institutes that have fine gage laboratories available for outside service. These are generally under the State Educational Office, and through them one can ascertain where such schools are located, and what facilities are available.

A second source of help in solving Inspection and Gaging problems is at some of the U. S. Government Arsenals. While they do not all possess gage laboratories, since their functions are in other fields such as manufacturing, there are at least two in the Eastern United States wherein the most modern equipment is maintained. These are Watervliet Arsenal at Troy, New York, and Frankford Arsenal at Philadelphia, Pa. Communications to the Director of the Gage Laboratory at either of these Arsenals will result in detailed information regarding your problem, or reference to another more intimate source.

The third reference suggestion for Inspection and Gaging help is doubtless the most complete facility. It is our National Bureau of Standards.

It has been my experience that this organization is not as well known, at least to the average individual, as it should be. It is certainly enlightening to read their annual report and find an amazing range of activity.

The Bureau is the "principal agency of the Federal Government for research in physics, mathematics, chemistry, and engineering. It acts as custodian of the Nation's basic scientific standards,

*Presented at the Fourth Annual Conference of the Instrument Society of America, Sept. 12-16, 1949, St. Louis, Mo.

†Associate Professor, Materials Processing, Sibley School of Mechanical Engineering, Cornell University, Ithaca, New York.

conducts research leading to improved measurement methods, and other basic practices." Its budget is in the neighborhood of seventeen million dollars per year. They maintain a staff of over 900 professional scientists and engineers, as well as some 600 technical assistants.

The activities of the Bureau are divided into four groups: Research and Development; Testing, Calibration and Standard Samples; Advisory Service; and Cooperative Activities.

Under the heading of Research and Development the effort is widely distributed. The range of topics is too broad to enumerate here, but some of the more attractive in our zone of interest were: The electronic micrometers; optical standard of length (Primary) one of 100 projects in optics; line standards of length; precision ring gages; precision angle gage blocks.

Approximately $740,000 was spent in 1947 on the conduct of 147,765 tests and calibrations. This work by the Testing, Calibration, and Standard Samples group is a gratifying accomplishment. Tapes, line standards, bars, along with a 1-kilogram and a 100-gram weight were certified. The latter two (for Australian National Standards Laboratory) were certified to a quality of 1 part in 5 million.

The Advisory Service is obviously a necessary adjunct to its other divisions of service. It would be absurd to think of this vast facility, with its aggregation of talent, to lay inert in this function—since the Bureau's origin was for service to the U.S.A.

Some conception of the cooperative work done by the Bureau may be garnered by the fact that more than 175 organizations and individuals supported research at the Bureau during 1947. It has been noted for its activity in the National and International projects on Weights and Measures.

Section Secretaries, Meeting Data and Programs

AKRON
Fred Appel, 932 Columbia Ct., Barberton, Ohio.
Fourth Tuesday. Meeting at 7:30 P. M., Akron Y.W.C.A.

ALBUQUERQUE
L. J. Paddison, 911 Parkland Circle, Albuquerque, N. M.

ARUBA
K. H. Walker, P. O. Box 389, c/o Lago Oil & Tranpsort Co., Ltd., Aruba, N.W.I.
First Tuesday. Meeting at 7:15 P. M.

ATLANTA
H. Kockritz, Fischer & Porter Co., 84 Peachtree St., Atlanta, Ga.
Fourth Monday. Meeting at 7:45 P.M., Ga. Institute of Technology.

BALTIMORE
George B. Greer, 631 E. 36th St., Baltimore 18, Md.
Second Friday.

BATON ROUGE
Jack L. Pillow, 801 Lake Park Drive, Baton Rouge, La., Meeting at 7:30 P.M., L.S.U. Geology Bldg.
March 2, "Pneumatic Circuits and the Force-Balance System of Measuring and Control," C. B. Moore.
April 3, "Gadgets," R. D. Webb, Carbide & Carbon Chemicals Corp.

BOSTON
C. J. Nazzaro, 456 Central Avenue, Milton 87, Mass.
Last Wednesday. Dinner at 6:30 P. M., Meeting at 7:00 P.M., Patten's Restaurant.

CALIFORNIA
D. C. Duncan, Helipot Corp., Meridian Ave., S. Pasadena, Calif.
First Tuesday, Dinner at 6:30 P. M. Meeting at 8:00 P. M.

CENTRAL ILLINOIS
H. F. Lange, 2101 W. Glen Avenue, Peoria 5, Ill.
First Wednesday. Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
H. F. Coffey, 4029 N. Temple Ave., Indianapolis, Ind.
First Tuesday. Meeting at 7:30 P. M.

CHARLESTON
S. E. Mitchell, 312 24th St., Dunbar, W. Va.
First Monday. Dinner at 6:30 P.M., Meeting at 8:00 P.M., Kanawha Hotel.

CHICAGO
Floyd E. Ertsman, Rm. 1420 Fisher Bldg., 343 S. Dearborn St., Chicago, Ill.
Third Tuesday. Dinner at 6:45 P. M., Meeting at 8:00 P.M., W.S.E. Auditorium.
March 7, "Instrument Shop Testing Equipment", Panel Session.
April 3, "Principles of Pneumatic Control," V. V. Tivy, Foxboro Co.

CHINA LAKE
A. G. DeBell, U. S. Naval Ordnance Test Sta., China Lake, Calif.

CINCINNATI
Edward H. Muhleisen, 320 Durrell Ave., Cincinnati 15, Ohio
First Monday. Meeting at 8:00 P.M., Eng'r. Society Hqs.

CLEVELAND
R. M. Woodside, 332 Oakmoor Rd., Bay Village, Ohio
Fourth Wednesday. Dinner at 6:30 P.M. Meeting at 8:00 P.M., Cleveland Eng'r. Society.

COLUMBUS
Orval Linebrink, c/o Battelle Memorial Institute, 505 King Ave., Columbus, Ohio
February 16, "Electrical Measuring Instruments," S. O. McCart, G. E. Co.

CUMBERLAND
Clyde Babst, 225 Cecilia St., Cumberland, Md.
Tuesday after Fourth Monday. Dinner at 6:30 P.M., Meeting at 8:00 P.M., Algonquin Hotel.

DETROIT
Seymour Sterling, 13331 Linwood, Detroit, Mich.
Second Wednesday. Meeting at 8:00 P.M., Rackham Bldg.

EASTERN NEW YORK
W. R. McKegg, c/o Gen. Engrg. & Consulting Lab., G. E. Co., Schenectady, N. Y.
First Tuesday. Dinner at 6:30 P.M., Meeting at 8:00 P.M.

GULF COAST
W. N. Sloan, 2558 Tyrrell Parkway, Port Arthur, Texas.
Third Tuesday. Meeting at 7:30 P.M., Lamar College.

HOUSTON
E. E. Kleir, c/o The Foxboro Co., 2518 S. Blvd., Houston 6, Texas
Last Monday. Meeting at 8:00 P.M., Engineers Club.
February 27, "The Manufacture of Starch for Food and Industry," T. H. Pierson, Corn Products Refining Co.
March 27, Banquet and Installation of New Officers.

KANSAS CITY
L. E. Oberhelman, Standard Oil Co., Sugar Creek, Mo.
First Tuesday, Meeting at 7:30 P.M., Univ. of Kansas City.
March 7, "Refinery or Chemical Process Control," Hart Fisher, Monsanto Chemical Co.

LOUISVILLE
H. C. Scherffius, 980 Palatka Rd., Louisville 8, Ky.
Fourth Tuesday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
L. J. Mizuhara, Monsanto (Canada) Ltd., 425 St. Patrick St., Ville LaSalle, Quebec, Canada
Last Monday, Meeting at 8:00 P.M. Mechanics' Hall.

NEW JERSEY
W. D. Archibald, 605 Westminster Ave., Elizabeth 3, N. J.
First Tuesday, Dinner at 6:00 P. M. Meeting at 8:00 P.M., Essex House.
March 7, "Instrumentation of a Cat. Cracker," Dr. Bergman, U. O. P.
April 4, Afternoon and evening Symposium on Measurement of pH and Conductivity.—2:00 P.M., a paper on pH by A. O. Beckman, National Technical Labs.—8:00 P.M., a paper on conductivity measurement by Dr. Rosenthal, Industrial Instruments Inc.

NEW ORLEANS
W. H. Haney, 2927 Music Avenue, New Orleans, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
Norman J. Cherry, P. O. Box 608, Merrick, L. I., N. Y.
Last Monday, Meeting at 7:30 P.M., Statler Hotel.

NIAGARA FRONTIER
Mrs. James L. Martin, 697 Potomac Ave., Buffalo 9, N. Y.
Fourth Monday. Dinner at 6:15 P.M., Meeting at 8:00 P.M., Institute of Arts and Sciences, Buffalo.
March 27, "Derivative Action in Automatic Controls," V. V. Tivy, Foxboro Co.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9, Texas

NORTHERN CALIFORNIA
M. A. Dimmick, 5607 Alta Punta, El Cerrito Calif.
Third Monday, Meeting at 7:30 P.M., Angelo's, Pasadena.
February 20, "Primary and Secondary Elements of Differential Flow Meters," a Panel Discussion.

NORTHERN INDIANA
J. Baum Beckman, 547 N. Waller Ave., Chicago 44, Ill.
Third Wednesday. Dinner at 6:30 P.M., Meeting at 7:30 P.M., Gary Y.M.C.A.
March 7, Joint Meeting with The Chicago Section.

OAK RIDGE
John H. Clark, 230 Canton Hall, Oakridge, Tenn.
First Wednesday. Dinner at 6:30 P.M., Meeting at 7:30 P.M., Oak Terrace.

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada
Third Thursday. Dinner at 6:45 P. M. Meeting at 8:15 P. M.

PHILADELPHIA
C. W. Wood, 6908 Market St., Upper Darby, Pa.
Third Wednesday, Meeting at 8:00 P.M., Bellvue Stratford Hotel.
February 15, "Pneumatic Operation for Diaphram Control Valves," D. P. Eckman, Conoflow Corp.

PITTSBURGH
Miss Louise Suckfield, P.O. Box 2038, Pittsburgh 30, Pa.
Fourth Monday. Dinner at 6:30 P.M., Meeting at 8:00 P.M., Roosevelt Hotel.
February 27, "Detection of Toxic and Explosive Gases," N. W. Hartz, Mine Safety Appliances Co.
March 27, "Automatic Control in the Oil Industry," H. F. Moore, Std. Oil Dev. Co.
Pittsburgh Inspection & Gaging Committee. Meeting at 8:00 P.M., Wm. Penn Hotel.
February 14, "The Laboratory and its Relation to Inspection," C. E. McFarlane, Westinghouse Air Brake Co.
March 14, "The Relationships between Engineering and Inspection," C. B. Johnson, Rockwell Mfg. Co.

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa.
Fourth Tuesday. Meeting at 8:00 P.M.
February 27, "Control Valves," T. L. Smith, Belfield Valve Div., Minneapolis-Honeywell Regulator Co.

RICHLAND
M. T. Slind, M-6, Rm. 107, Richland, Washington
Second Wednesday. Meeting at 7:30 P.M., American Legion Hall.

ROCHESTER
R. C. Schwarz, Jr., 1201 Granite Bldg., Rochester 4, N. Y.
Fourth Tuesday. Meeting at 8:00 P.M., Univ. of Rochester, Physics Lecture Hall.

SARNIA
Fred T. Yorke, P. O. Box 213, Point Edward, Ontario, Canada
Second Friday, Moose Hall.

SOUTH BEND
Sam M. Rouse, 436 Moccasin Ave., Buchanan, Mich.
First Thursday. Meeting at 8:00 P.M., Engineers Club, Hotel La Salle, South Bend.

SOUTH MICHIGAN
Larry DeHann, 1117 Cobb Ave., Kalamazoo, Mich.
Second Wednesday. Dinner at 6:30 P.M. Meeting at 8:00 P.M.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Falfurrias, Texas

Continued on page 188

ISA Committees Continued from page 181

Committee for Analysis Instrumentation: D. J. POMPEO, Chairman, (No. Calif), 842 Cleveland St., Oakland 6, Calif.

Committee on Instrumentation for Production Processes: D. M. BOYD, Chairman (Chi), 315 Ridge Ave., Clarendon Hills, Ill.

Instruments for Inspection and Gaging Committee: R. L. GEER, Chairman, (N. Y.), 138 Giles St., Ithaca, N. Y.; R. W. Carson (N. J.), 2 East Main St., Little Falls, N. J.; W. A. MacCrehan, Jr., Dept. Adm. Engr. N.Y.U., University Heights, N. Y. 53, N. Y.; E. C. Polidor, Engineering Specialties Div., 1055 Mercantile Bldg., Rochester, N. Y.; J. W. Huether, (Ont), Canada Wire & Cable Co., Leaside, Ont., Canada.

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Instrument Calibrating Techniques *Sub-Committee*: A. K. JOECKS, Chairman, (N. Y.), Consolidated Edison Co., 708—1st Ave., N. Y. 17, N. Y.; G. A. Pettit, P.O. Box 96, St. Louis, Mich.

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Section Data Continued from page 187

First Thursday. Meeting at 7:30 P.M. ... Aircraft Instrument School.

ST. LOUIS

W. G. Lee, 4710 Delor St., St. Louis ... Mo.
First Wednesday, Meeting at 8:00 P.M. ... Engineers' Club of St. Louis.
March 8, "Chemical Process Control ... Hart U. Fischer, Monsanto Chemical Co.
April 5, "History of Feed Water Reg... ...ors" D. Allhouse, Northern Equip. Co.

TENNESSEE

N. M. Taylor, 16 Edgewood, Kingsport ... Tenn.
No definite night, Dinner at 6:45 P.M. Meeting at 8:00 P.M.

TULSA

C. R. Horton, 8211 E. 7th, Tulsa, Ok... ...homa
First Monday, Meeting at 6:45 P.M. ... Engineering Bldg., Tulsa Univ.

TWIN CITIES

Alden Hine, c/o Giesika & Pinkney, ... Plymouth Bldg., 6th & Hennepin Ave., Minneapolis 2, Minn.
Fourth Tuesday, Dinner at 6:30 P.M.

WASHINGTON

Raymond E. Miller, 20-224 Naval Ord... Lab., White Oak, Md.
Third Monday, Meeting at 8:00 P.M., F. E. P. Co. Auditorium.

WAYNE COUNTY

Robert Karr, 2455 Biddle Ave., Wyandotte, Michigan
Third Monday, Dinner at 6:30 P.M., Meeting at 8:30 P.M., Poremba Hotel, Ecorse, Mich.

WILMINGTON

Dean Valentine, 34 N. Hill Drive, West Chester, Pa.
Third Tuesday, Meeting at 8:00 P.M. Harlan Public School, Wilm.

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• • •

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JOURNAL of the
Southern California Meter Association

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Past-President: J. C. Groenewegen

REPORT *on the* METHODS *Used in the* 1949 AGA-ASME Orifice Meter Tests

By F. M. PARTRIDGE, Southern California Gas Company

PRESENT practice in California is to determine orifice meter coefficients by use of tables in publications of the California Natural Gasoline Association. These tables are based on data in "Gas Measurement Committee Report No. 2" of the Natural Gas Department, American Gas Association, which is a final report on a series of tests conducted during the period from 1924 to 1935. The Fluid Meter Research Committee of the American Society of Mechanical Engineers collaborated with the A.G.A. Committee in some of its work and in the preparation of the final report.

The tests upon which the above reports were based were conducted almost exclusively with orifice plates installed between flanges and resulted in valuable data on basic orifice coefficients, pressure tap locations and lengths of orifice tubes required for accurate gas measurement.

In the years since "Gas Measurement Committee Report No. 2" was written there have been developed several new or different methods of installing orifice meters which are not covered in the report. To determine what effect these newer practices have on measurement and to recognize and approve the use of orifice fittings and bored meter runs, an AGA-ASME Joint Committee on Orifice Meters was appointed to conduct a series of tests and prepare a report covering the following subjects.

1. *Disturbance Tests.* These tests are to determine the effect of various valves and fittings upstream from the orifice meter and to determine the minimum lengths of meter tubes to be used under certain standard conditions.

2. *Effect of Plug Valve and Elbow Disturbances.* These tests are to determine the effect of various plug valves in the upstream meter run and also in the riser upstream from the meter run.

3. *Effect of Pipe Sizes.* It is desirable to obtain additional data on which to base the practice of using data obtained with one size meter on a meter of different size. This work will include performing similar tests on 2-in., 4-in. and 8-in. meters and comparing the results obtained.

* Presented before the Southern California Meter Association, January 19, 1950.

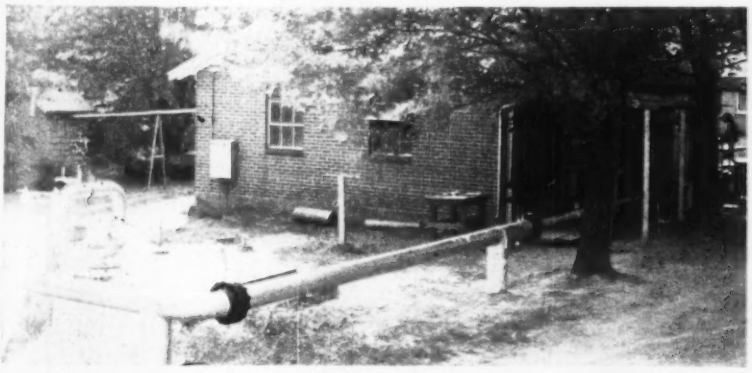

Fig. 1. Rockville Measurement Station of the Atlantic Seaboard Corporation

MARCH MEETING: Thursday the 16th, Rio Hondo Country Club, Downey, Calif. Dinner at 6:30; meeting 8 sharp.
FEATURE: "Gas Regulation and Control" by J. H. Cope (Fisher Governor Co.) Marshalltown, Iowa.
Non-members cordially invited.
—THERON S. CODY
Publicity Chairman

4. *Size and Location of Pressure Tap Holes.* It is felt that additional data are needed on the proper size and location of pressure tap holes, particularly flange taps which are now located 1 inch from the plate regardless of the size of the meter run.

5. *Comparison of Select Pipe with Bored or Machined Meter Tubes.*

6. *Comparison of Orifice Fittings and Standard Flanges for Holding the Orifice Plates.*

The tests to date have been principally in connection with Item 2, Effect of Plug Valve and Elbow Disturbances. With the benefit of the experience gained on these tests it is probable that the remaining tests will progress more rapidly and may be completed by the end of 1950.

The tests were started in the early part of 1949 at the Rockville Measurement Station of the Atlantic Seaboard Corporation about 15 miles from Washington, D. C. It is at this Station that the gas for the City of Washington is delivered to the Washington Gas Light Company. A general view of the Measurement Station and testing set-up is shown in Fig. 1. A diagrammatic sketch of the reference and test meter piping is shown in Fig. 2. The rate of flow was regulated with the parallel 8-in., 2-in. and ½-in. valves shown at the left center (also see Fig. 6) and the static pressure was controlled by partly closing the outlet valve.

The numbered sections shown in Fig. 2 are the test sections which were

jointed with flanged connections. The dimensions of the test sections are as follows:

DESCRIPTION OF SECTIONS

Section	Size in.	Length ft. in.	Remarks
1	8	21 0	
2	4	21 0	4 x 8 in. reducer at one end
3	4	8 0	
4	4	7 6	Includes 4 in. plug valve and 2 in. by-pass
5	4	3 6	
6	4	5 9	
7	4	5 9	
8&9	4		End sections including 3 ells
10	4	5 9	
11	4	5 9	
12	4	3 6	
13	4	3 6	
14	4	6 0	4 in. plug valve and 4 x 8 in. reducer at downstream end

All sections have 400-lb. A.S.A. flanged ends. Similar sections will be used for tests with 2 in. and 8 in. meter runs.

Inasmuch as orifice meters are inferential meters, some means must be provided for calibrating the meter under all desired operating conditions. For these tests a reference meter is used that is always operated under the same conditions.

By always testing the same two orifice plates in series and conducting each series of tests at the same flow rate it can be shown that the general orifice meter equation.

$$Q = 338.2 K_0 d^2 \sqrt{\frac{1}{G}} \sqrt{\frac{520}{T}} \sqrt{Y} F_{e2} F_R \sqrt{h P_2}$$

can be greatly simplified by eliminating the factors

$$338.2 K_0 d^2 \sqrt{\frac{520}{G}} F_R$$

Q = Quantity of flow in standard cubic feet per hour.
K_0 = Orifice discharge coefficient.
d = Orifice diameter, inches.
G = Specific gravity of gas, air equals 1.00.
T = Temperature of flowing gas, degrees F. absolute.
Y = Superexpansibility factor.
F_{e2} = Expansion factor.
F_R = Reynolds number factor.
h = Differential pressure across orifice, inches of water.
P_2 = Pressure of flowing gas at downstream pressure tap, psia.

In comparing results obtained from the reference and test meters it is not necessary to compute the cubic feet of gas passing through each meter and then determine the percentage difference. This difference can be obtained directly by dividing the simplified flow equation for the test meter by the simplified flow equation for the reference meter. The resulting ratio is called the "Test Meter Factor" and is designated by the letter F. Thus:

$$F = \frac{\left[F_{e2} \sqrt{\frac{h P_2}{T}} \right] \text{Test Meter}}{\left[F_{e2} \sqrt{\frac{h P_2 Y}{T}} \right] \text{Reference Meter}}$$

Each different set-up of the test sections is termed a "Combination." For each "Combination" an extensive set of tests are performed under four rates of flow with each of seven different sizes of orifice plates installed in the meters. The pressure of the flowing gas was generally between 120 and 200 psig. and the four flow rates were set at a differential pressure of approximately 10 in. and 50 in. of water column and 10 in. and 50 in. of mercury. The orifice sizes used were:

	Reference Meter		Test Meter	
	Size Plate	Beta	Size Plate	Beta
1.	1.250	0.310	1.250	0.310
2.	1.625	0.404	1.625	0.404
3.	2.500	0.621	2.500	0.621
4.	2.875	0.714	2.875	0.714
5.	3.125	0.776	3.125	0.776
6.	3.2187	0.800	3.375	0.838
7.	3.2187	0.800	3.500	0.870

The four flow rates with each of seven different orifice sizes make a total of 28 tests that are run for each different "Combination" of test sections. The high beta ratios used on the test meter are applicable principally to steam measurement where it is desirable to keep pressure losses to a minimum. It was not deemed advisable to exceed a beta ratio approximately 0.8 for the reference meter.

Four different sets of pressure taps are connected and used on the test meter located as follows:

Flange Taps—1 in. upstream and downstream from the respective orifice plate faces.

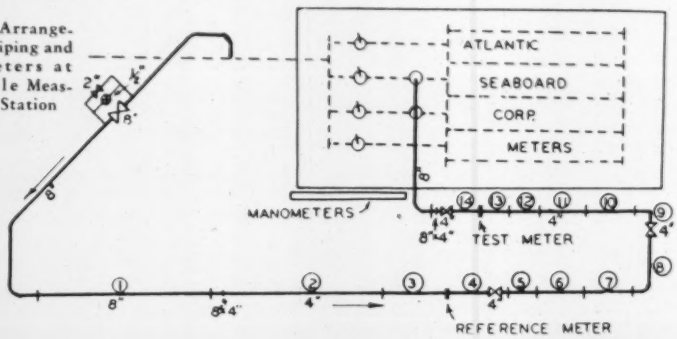

Fig. 2. Arrangement of Piping and Test Meters at Rockville Measurement Station

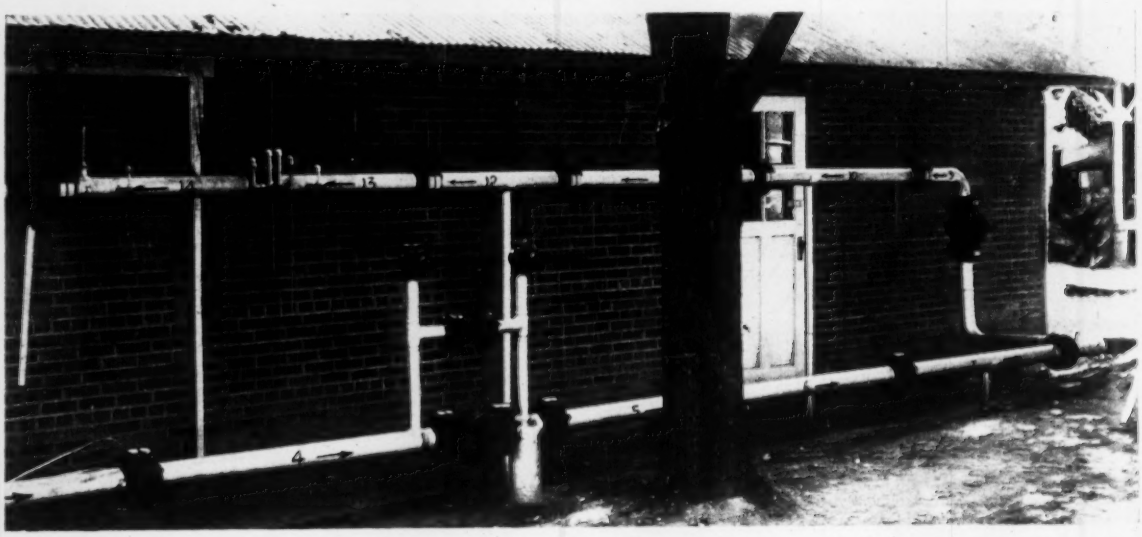

Fig. 3. View of the Reference and Test Meters

Pipe Taps—2½ pipe diameters upstream and 8 pipe diameters downstream from the upstream face of the orifice plate.

Throat Taps—One pipe diameter upstream and ½ pipe diameter downstream from the upstream orifice plate face.

Corner Taps—The pressure tap holes open in the corner formed by the pipe wall and the orifice plate. The corner taps are quite generally used in Europe and were included in the tests for this reason.

Flange taps only are used on the reference meter.

Pressure Measurements

Static pressures are measured by use of a dead-weight gage with fractional weights which accurately indicate pressures to 0.1 psi. The difference between the static pressure on the flange taps and the static pressure on the corner, throat, and pipe taps is measured by manomters and the static pressures for the corner, throat, and pipe taps are then determined by adding or subtracting this difference as measured by the manometers to the pressure measured by the dead-weight gage.

All differentials are measured by U-type manometers, 60 inches long, with 0.1-in. divisions. On each pair of taps two manometers are manifolded together, one filled with mercury and the other with water so as to cover the desired differential range.

Flowing temperature measurements are made using mercurial thermometers with 1-degree F. divisions. Three thermometers are used, one upstream, one between the reference meter and the test meter, and the other downstream from the test meter.

The assembly of manometers and dead-weight gages used in the tests is shown in Fig. 4. Starting at the extreme right are shown: (1) the mercury and water manometers for the reference meter, (2) the dead-weight gage connected to the reference meter, (3) the dead-weight gage connected to the flange taps of the test meter, (4) the mercury and water manometers for the test meter flange taps, (5) a well-type manometer to measure the difference in static pressure between the test meter flange taps and the pipe and throat taps, (6) the mercury and water manometers for the test meter throat taps, (7) for the pipe taps, (8) for the corner taps, and (9) on the left is another well-type manometer to measure the difference in static pressure between the test meter flange taps and the test meter corner taps.

Method of Test

Each test run is performed in the following manner. The flow rate is adjusted by means of the inlet valves (see Fig. 6) until the desired differential corresponding to the flowing pressure is obtained. The flowing pressure is adjusted as necessary by means of the outlet or the intermediate valve

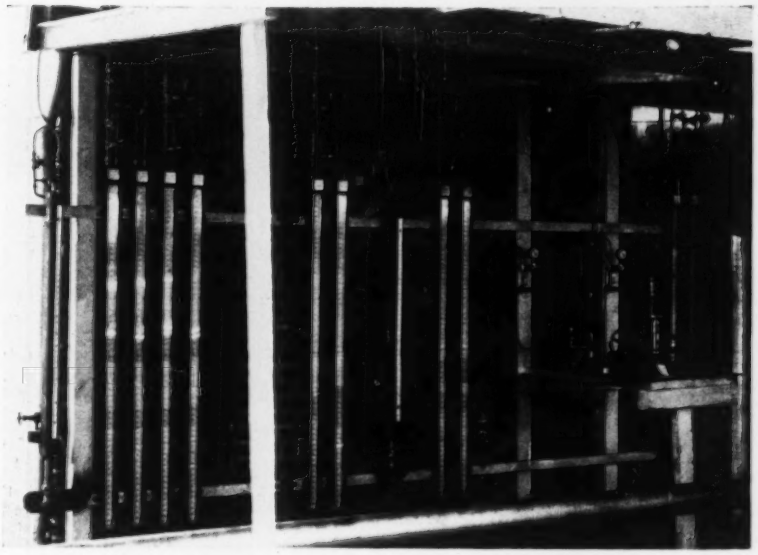

Fig. 4. Manometers and Dead-weight Gages

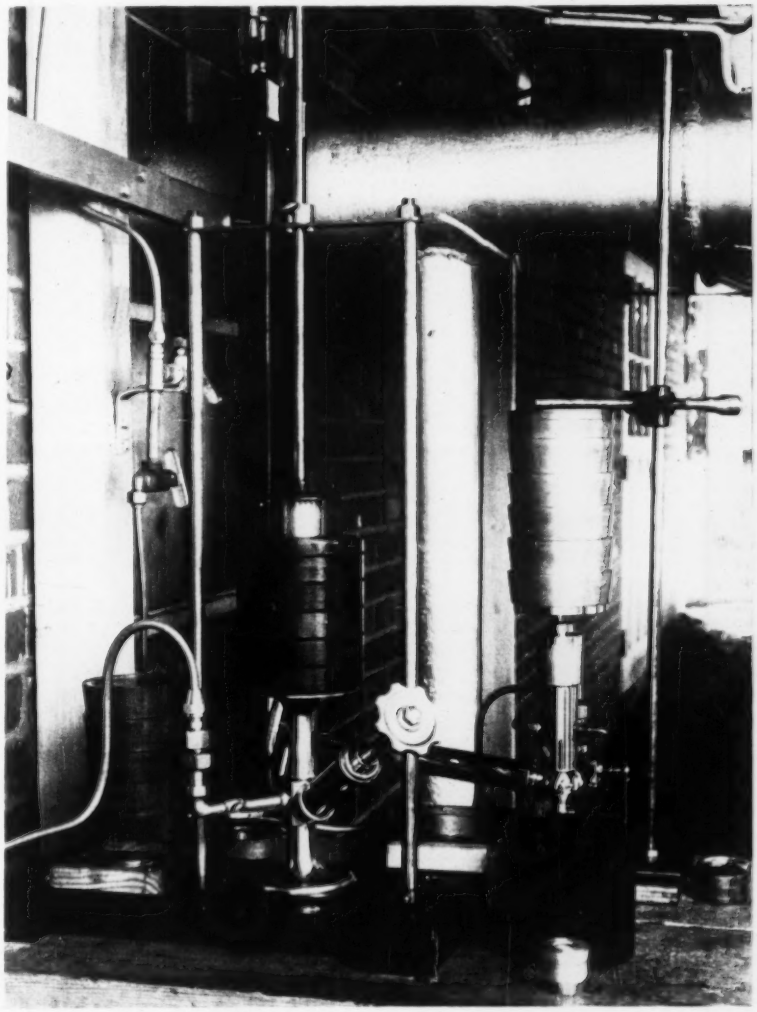

Fig. 5. Close-up of Dead-weight Gages

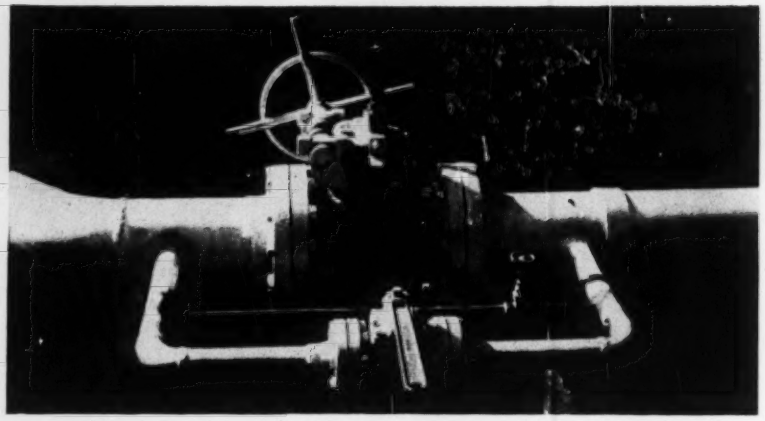

Fig. 6. Valve Assembly used for Controlling Flow Rates

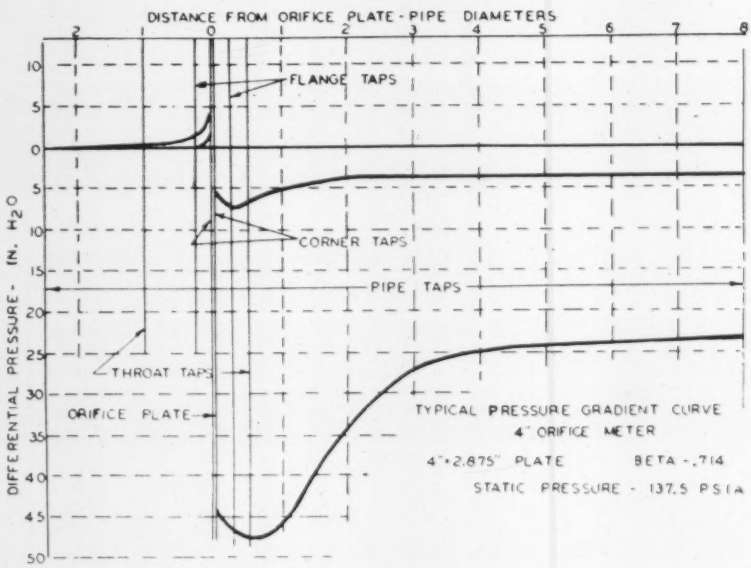
DISTANCE FROM ORIFICE PLATE - PIPE DIAMETERS
2 1 0 1 2 3 4 5 6 7 8
10 5 0 5 10 15 20 25 30 35 40 45 50
DIFFERENTIAL PRESSURE - IN. H2O
FLANGE TAPS
CORNER TAPS
PIPE TAPS
THROAT TAPS
ORIFICE PLATE
TYPICAL PRESSURE GRADIENT CURVE
4" ORIFICE METER
4"×2.875" PLATE BETA - .714
STATIC PRESSURE - 137.5 PSIA

Fig. 7. Pressure Gradient Curves in Vicinity of Orifice

as required. After the flowing conditions are in equilibrium the actual readings are taken on the manometers and dead-weight gages shown in Fig. 4. Each test consists of a series of ten readings of each instrument taken simultaneously at thirty second intervals for the five minute duration of the test. A buzzer operated by an electric timer indicates the proper time to record the readings.

To calibrate the test meter, sections 8 and 9 (Fig. 2) were removed and a calibration section which included only two ells and straight pipe was installed. A complete series of 28 five-minute tests (four different rates with each of seven different orifice plates) were run and used as a basis for comparing the results obtained with the test meter when used with the various test "Combinations." By dividing the "*F*" ratio obtained with a given test "Combination" by the "*F*" ratio obtained on the calibration tests and multiplying by 100 the effect of any given "Combination" on gas measurement accuracy could be determined on a percentage basis.

The first tests after the calibration run was complete were run with sections 8 and 9 reinstalled in the line as shown in Fig. 2. The 4-in. plug valve shown in section 9 was alternately installed in the riser and in the test meter run and a series of 28 tests conducted in each position. When this test was completed sections were successively removed starting with Numbers 7 and 10 and the tests repeated at each step. Up until the end of October 1949, approximately 850 tests had been run completing 28 test "Combinations" and sections 5, 6, 7, 10, 11, and 12 had been removed. These tests consisted of testing three different types of plug valves located both in the riser and in the meter run at distances from 10 to 55 pipe diameters upstream from the test meter. Straightening vanes were not used on these tests but it is planned to repeat the more critical tests with straightening vanes installed.

Results

Conclusive results from these tests will not be available until the figures obtained from the individual tests are averaged, plotted, and analyzed. The results of one test cannot be regarded as conclusive. It is not until the results of a great number of tests are analyzed that confidence can be placed in them and they can be used as a basis for commercial gas measurement.

The use of four sets of pressure tap holes on the test meter made it possible to obtain a graphic illustration of the pressure conditions in the vicinity of the orifice. Particularly interesting is the pressure variation very close to the orifice plate that is revealed by the corner taps. Fig. 7 shows a curve for one particular orifice under two different flow rates. For the higher rate the differential at the upstream plate face was more than four inches water column higher than at a point 2½ pipe diameters upstream. The pressure dropped practically instantly across the plate so that at the downstream face the pressure was approximately 48 inches water column lower than at the upstream face. The pressure then continued to drop until the vena contracta was reached and then rapidly increased until at eight pipe diameters downstream the pressure was only about 23 inches lower than it was at the tap located 2½ pipe diameters upstream from the plate. This illustrates the importance of the proper location of the pressure taps, particularly flange taps, and the need for additional test work to determine the best locations for them. Fig. 8 shows the special

Fig. 8. Special fitting for use in testing the effect of size and location of pressure tap holes.

spacer rings that have been made up for use in conducting tests to determine the proper size and location of pressure tap holes for the most efficient and accurate gas measurement. There are 14 sets of pressure tap holes of various sizes and locations in these spacers.

Conclusion

It is anticipated that much good and valuable data will result from the work being done by the AGA-ASME Joint Committee on Orifice Meters and that the final report on the project will make possible the use of newer meter installation methods and will be another step toward more dependable gas measurement with orifice meters.

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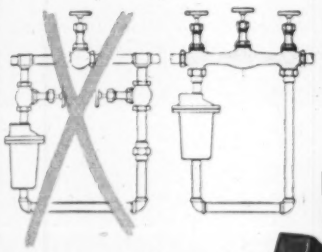

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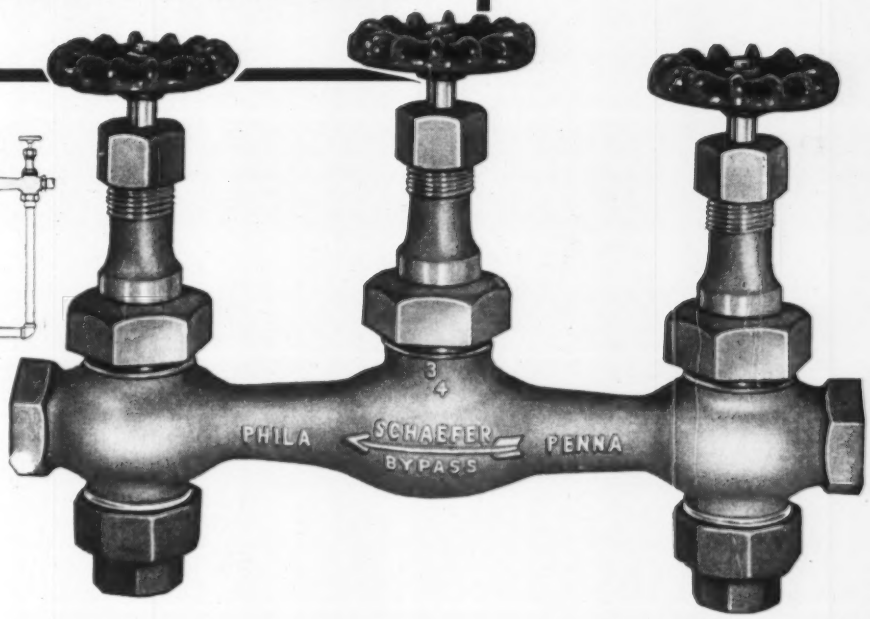

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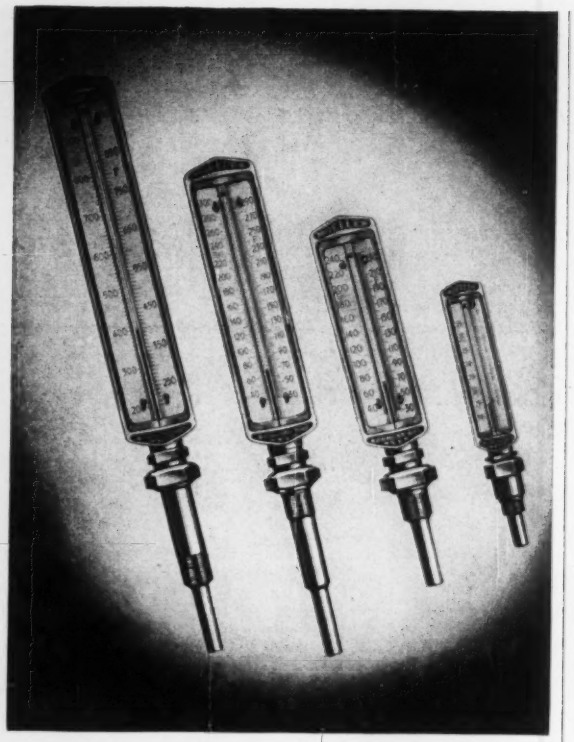

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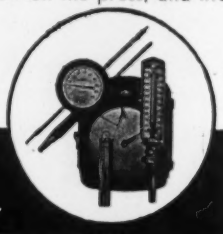

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Regulation of pH

Continued from page 152

agent is added to the surface or body of tank contents, but is not serious in many cases because of the nature of reactions.

The reagent should, wherever possible, be introduced into a residence at a point of small cross-sectional area, namely the inlet as illustrated in Fig. 79. This is especially true when "burning" or decreased yields result from localized over-treatment, or where occlusion may result from contact of suspended matter or precipitates and concentrated reagents. As a general rule, unless unusual conditions are involved, reagent should contact the process liquor by expanding into an environment of increasing concentration rather than the reverse. Reactions are more stabilized and the regulator has better command of the process.

> There are a number of examples of this effect in chemical processing and some are commonplace experiences. Probably everyone is familiar with the explosive results of pouring water into concentrated sulphuric acid while the reverse procedure is less hazardous. Crystalline structure of precipitates is, in many cases, dependent on the order of mixing reagent and process medium while other reactions require a definite order and concentration of admixture to avoid precipitation or so-called "case hardening" (trade nomenclature) of product. Some pharmaceutical preparations require the addition of a small low-concentration stream of process liquor to a large volume of concentrated salt or acid to obtain the desired end product. The reverse order produces an entirely different product. There are numerous other examples of the effect of concentration gradient on the quality of product or the ratio of yield of main product to side products: Changing the concentration gradient will change the products derived from many given process reactions. So far as this effect is concerned, one may, in some cases regard the process liquor as the reagent, and the reagent as the process liquor.

The figure of merit or effectiveness of reagent in bringing about a pH change is determined by its concentration or the equivalents of reactant per gallon of solution. A gallon of 10 percent reagent has considerably greater effect (not twice) in changing pH of a process than the same volume of a 5 percent solution added in the same increment of time. Or a 5 percent solution will cause a greater change in pH than a 2 percent reagent for a given throttling range of the control valve. If the concentration is reduced, the throttling range must likewise be reduced to compensate for a given load change in a given process. Conversely, if reagent concentration is increased, the valve throttling range must likewise be increased—but there are practical limits in either direction. As the reagent strength is reduced, the time required to add a given number of equivalents of active chemical to the process is increased for a given valve rate and instrument response. Stronger reagents may be so reactive that valve motion cannot be stabilized within the limitations of lost motion or hysteresis of the valve.

Average concentrations of reagent for most common pH applications varies from 0.5 percent (by weight) to 15 percent for proportional-position regulators, depending on specific applications. Special applications may require higher concentrations but in every case there will be found an optimum ratio between valve size and reagent concentration for a given reaction period of the regulator. Adjustments in reagent concentration may be found more effective at a fixed throttling range in stabilizing control than the reverse order adjustments, but any reduction of concentration will also reduce the effective pH rangeability of the valve. There is a theoretical approach to optimum conditions but, in many cases, reagent concentration is fixed by other factors pertaining to the chemistry of reactions and the control engineer is forced to accept this limitation in designing the control application.

Cascaded regulators may offer advantages in some cases and use may be made of techniques developed for other control applications. Effective rangeability of temperature control valves has been widened by parallel operation of two valves of different sizes (or of equal size) with one acting

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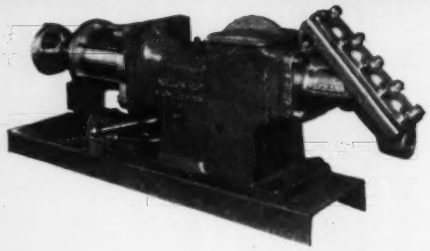

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as an "enricher" to blend a higher-Btu. gas (propane) with the lower Btu. control gas. The same technique may be applied to widen effective rangeability of pH control valves, as illustrated in Fig. 89.

It is not desirable from a cost standpoint to handle very dilute reagents because large storage tanks may be required for batch preparations. However, it may be possible to install a continuous dilution system using cascaded regulators similar to Fig. 62 or a positive displacement proportioning pump (Fig. 90) as has been done successfully in some cases.

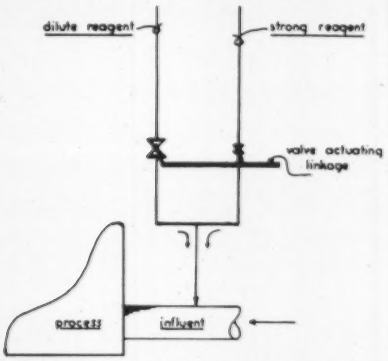

Fig. 89. Parallel-coupled valves controlling flows of different strength reagents, widening effective rangeability of pH control valve.

On the other hand, reagent concentration is sometimes fixed by the chemistry of process reactions and the control engineer is forced to use small-size valves of special construction. Two of the three adjustable variables are thus fixed leaving but one degree of freedom namely, throttling range adjustments, or, possibly, selection of a different mode of regulation. Moreover, drop-feed valves feeding highly concentrated reagent may be objectionable because of dis-

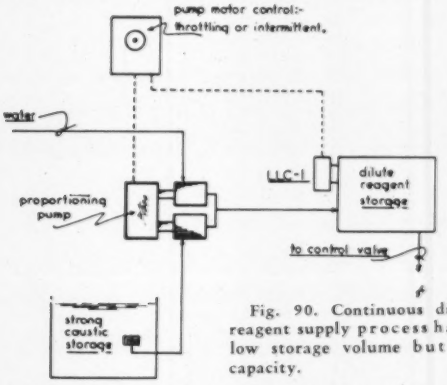

Fig. 90. Continuous dilution reagent supply process having low storage volume but high capacity.

continuity of feed and it would seem more desirable to use a controllable diffusion device. Some engineers have reported favorable results with multi-stage (two-piston) positive-displacement feed pumps for small-volume reagent feed.

* * *

The importance of concentration gradient and reagent strength may not be apparent to the control engineer unfamiliar with the chemistry of process reactions and he may be at a loss to understand why it is possible to obtain satisfactory control under certain conditions and not others. This is the partial subject of another paper now in preparation and will not be discussed in detail here. However, the problem is of importance in pH control and Figs. 91 and 92 may serve to acquaint the control engineer with some limiting effects involved.

Fig. 91 illustrates the relative effects of alumina concentration and pH range of floc formation in water treatment processing. Not only does the lower alumina concentration precipitate less floc but the range of effective pH control is diminished and the equivalence point (optimum control

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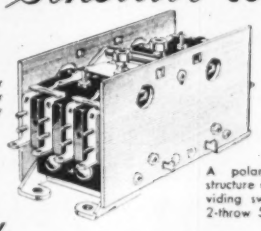

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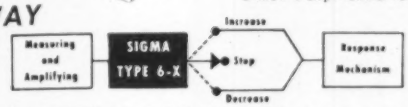

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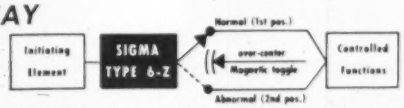

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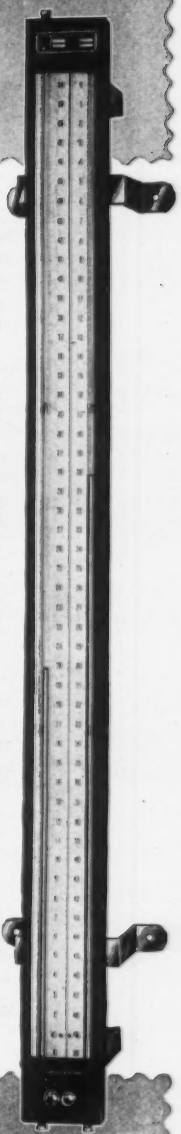

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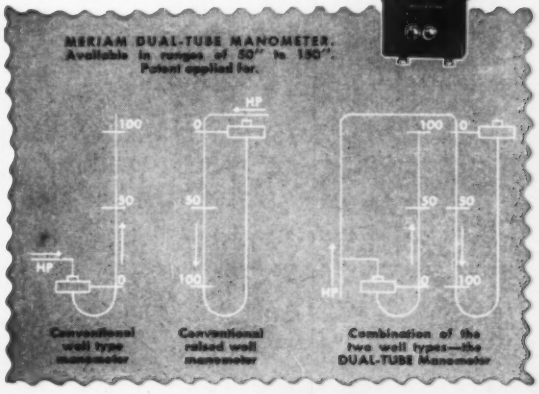

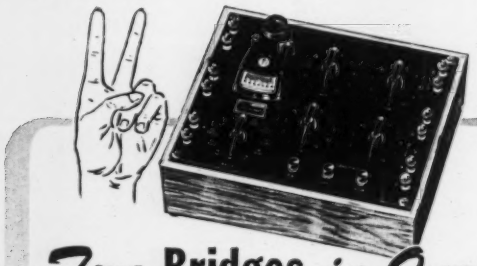

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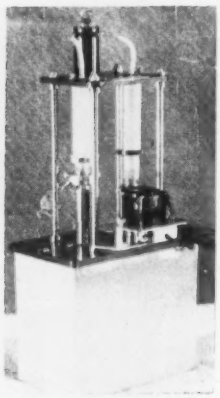

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point) shifted. This may appear to be pure process chemistry without bearing on control behavior, but it must be borne in mind that shifting of the equivalence point of any control installation may affect its equilibrium lag and introduce characteristic instability of control which, in most

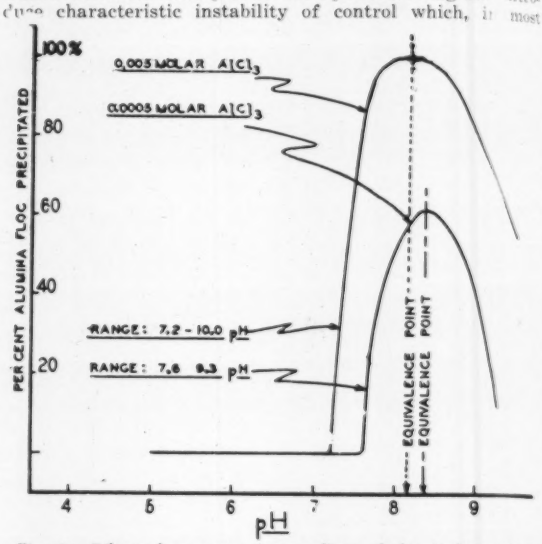

Fig. 91. Effect of concentration gradient of chemical process on control point variations.

cases, can be corrected by operating at a lower concentration gradient.

Reagent strength is highly important and, in many cases, must be held uniform and constant particularly where delayed flocs or precipitates are formed as a result of interaction with process liquors. If concentration of reagent or process liquor changes, the result may be as indicated in Fig. 92. The controller may "see" one pH and attempt to control at that value within a given bandwidth but the *effective* process pH will be offset by an amount dependent upon its concentration gradient. The process may respond differently and not necessarily at the same band width. Furthermore, the time relationship between concentration and pH, as given in Fig. 92, establishes equilibrium lag

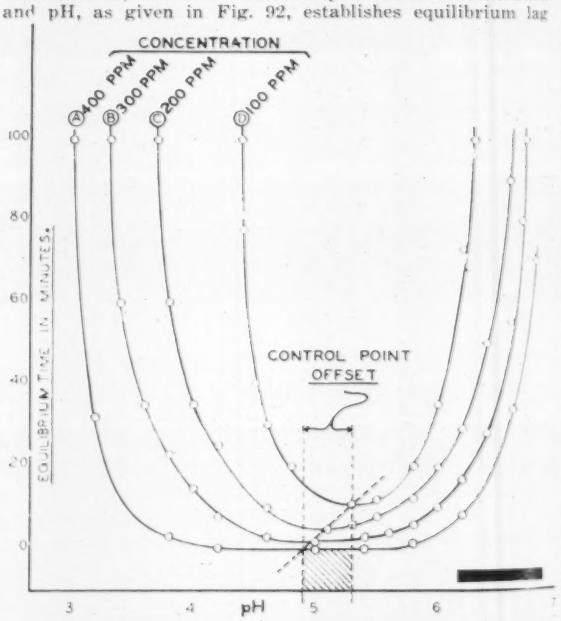

Fig. 92. Effect of reagent concentration on apparent control point. If concentration changes, the process effective control point may shift and not respond at the rate indicated by the controller.

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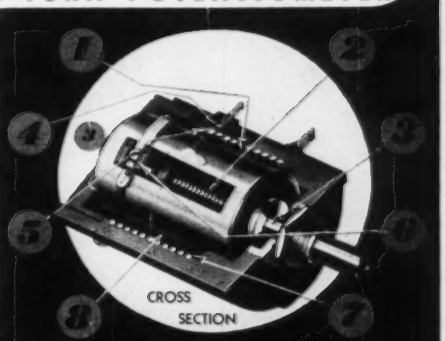

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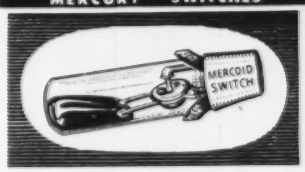

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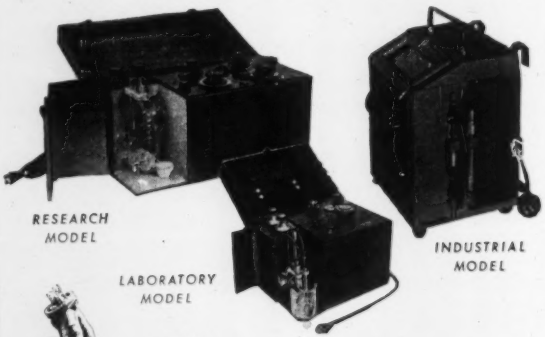

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with its characteristic effects as given in the foregoing chapters.

It is not sufficient that the "process chemistry" of a control installation be ignored with the defense that a "good instrument" has been applied and is faithfully recording what it sees and that the instrument engineer has done his job. Our purpose in applying a pH controller is to bring about some desired end result in the process, not the instrument, and it is especially necessary that process chemistry be recognized and understood to achieve good control of pH or other similar *concentration* variables.

Too often, ignorance of this condition has led to User dissatisfaction. The equipment supplier has defended the mechanical and electrical performance of his equipment yet the User did not achieve the results expected. Control installations have been condemned and removed whereas an appreciation of the effects of concentration gradient and equilibrium lag by either party might have meant a satisfied User.

B—Gaseous Reagents

The effect of temperature on gaseous reagents usually is to increase reactivity but it may also decrease solubility of the gas and special "gassing" devices are sometimes required to minimize short-circuiting in the reactor and loss of good reagent up the stack. Pressure also affects reactivity of gaseous reagents and may require regulation if the process is operated at pressures different from atmospheric.

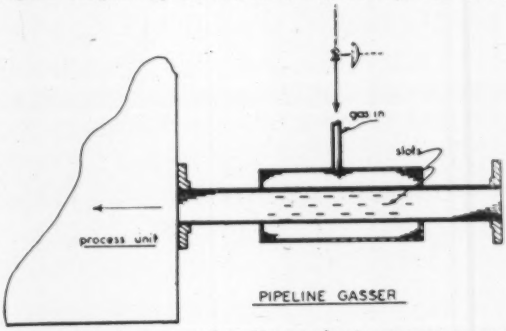

Fig. 93. Pipeline gasser for pH control using gaseous reagent.

Gaseous reagents commonly used in pH control are acid or basic anhydrides such as sulphur dioxide, carbon dioxide, chlorine and anhydrous ammonia, although others may be used for special problems. Frequently, the source of carbon dioxide is boiler flue-gas containing approximately 12 percent active gas, while other applications may require pure gas usually obtained from cylinders or dry-ice gas generators. Sulphur dioxide is usually obtained more economically from sulphur burners, although it too may be used in bottled form for small-scale pilot operations. Concentration of gaseous reagents affects their reactivity similarly to liquid reagents and they are sometimes diluted with an inert gas (air or nitrogen) to prevent "over-control."

The problem of injecting gaseous reagents most effectively to minimize short-circuiting and localized over-treatment is best exemplified by applications in the beet sugar industry. It has been pointed out above with reference to Fig. 70 that losses due to localized burning and inversion of sugar and attending losses of gas up the stack are large compared to the low-residence process of Fig. 71. The reason for this is the manner in which the gas contacts descending juices and short-circuits and channels through packing of the high residence chamber. This condition has been improved by flash gassing in a small-residence "gasser" followed by a high residence equalizer (Fig. 71.) Sugar yields are higher and sulphur losses lower in the latter process.

Still further improvements have resulted by "gassing" in a pipe line diffuser (Fig. 93) which distributes the reagent more uniformly over a small cross-sectional area of influent liquor and minimizes localized over-treatment. However, limitations of this technique prevent its widespread use in all gassing problems where precipitation occurs, as for

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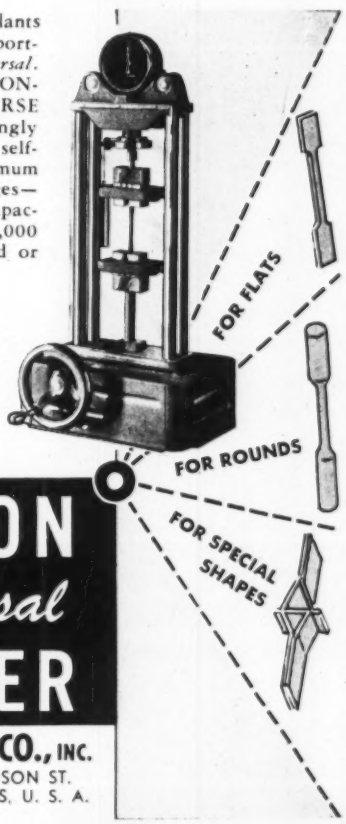

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example pre-gassing of sugar-beet extracts with carbon dioxide to remove calcium which may form an incrustation over pores of the diffuser.

* * *

In most applications of gaseous reagent control, pressure drop across the control valve is restricted to the range below 50 psi. and the valve is short-connected to the process unit with piping arrangement and check valves to prevent reverse liquor flow. Pressure regulators are installed ahead of the control valve and sometimes a surge chamber is used after the regulator to equalize pressure during throttling action of the control valve. If the gas supply pressure is high, it is customary practice to install a pressure relief valve after the pressure regulator to avoid emergency damages. In many cases, it is necessary to avoid moisture in reagent gases to prevent corrosion and gumming or sticking of the valves and regulator.

C—Solid Reagents

Before pH changes can result from the addition of solid reagent, it must first dissolve; and, invariably, this type of reagent introduces equilibrium lag and sometimes occlusion. If the reagent is composed of active material with much inert matter, it is particularly troublesome in low acidity solutions near the neutral range. Sometimes burnt limestone is slaked and used as a slurry for neutralization in water treatment and sewage disposal operations. In such cases the unburned carbonate occludes process liquors and introduces equilibrium lag which usually requires long time settling to reach equilibrium. In one such case, it was not only impossible to obtain a good control record but the concentration of inert solids was so high it etched the glass electrode irreparably in less than two weeks' time. High acidity neutralization jobs are usually less troublesome in this regard since carbonate is also attacked by the strong acids.

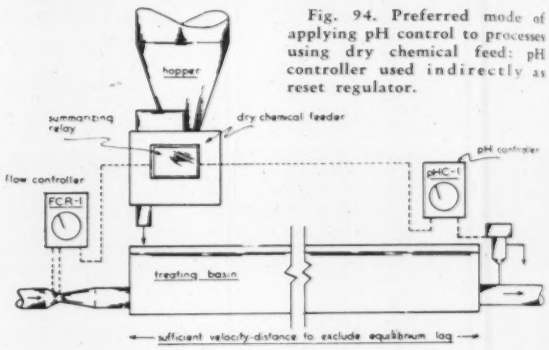

Fig. 94. Preferred mode of applying pH control to processes using dry chemical feed: pH controller used indirectly as reset regulator.

The use of dry reagents is most commonplace in water-treatment and sewage-disposal plants where large-quantity consumption demands the more economical handling and storage facilities of solid reagents. Whether benefit derives from the application of pH controllers directly to feed regulation of dry chemical is questionable, and may be wholly contingent on conditions of the process. Customary practice is to feed dry chemical as a function of flow of process water and it seems that wherever pH control is of importance, it could best be applied indirectly as a reset device cascaded with standard flow-ratio reagent feed (Fig. 94) in keeping with preferred practice. The important feature of this method is the time factor after reagent addition which permits equilibrium lag to stabilize.

Conclusion

Many pH control applications have become standardized to the point of catalog items while others introduce special features characteristic of their individuality. Problems of one application may be wholly physical while others may have chemical limitations and only by rigid separation and classification of all factors involved in a pH process, together with an understanding of their characteristics, can the process be most effectively instrumented.

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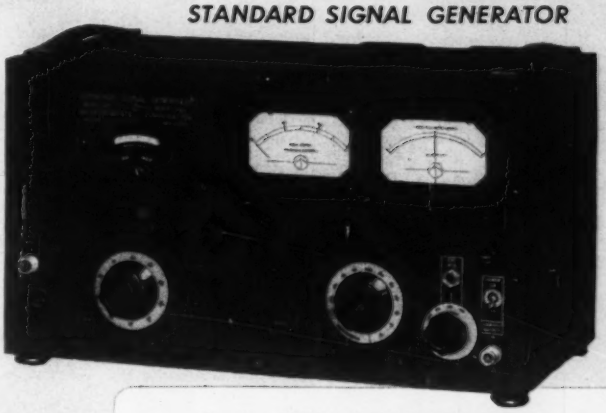

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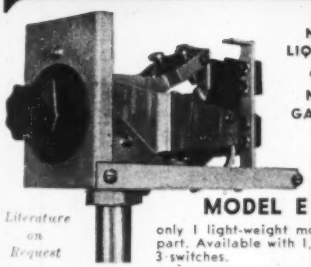

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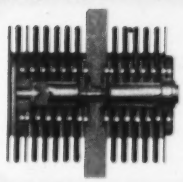

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 207.

S-67 ELECTRONIC HARDWARE. 4-page bulletin lists maker's standardized electronic hardware; gives capacities, sizes, prices.—U. S. Engineering Co., 521 Commercial St., Glendale 3, Calif.

S-68 CIRCUIT PANEL. 4-page bulletin describes and illustrates maker's "Model 104" circuit panel and charts for experimental electronics, instruction and research; also maker's multiple power supply for use with circuit panel.—Kepco Laboratories, Inc., 149-14 41st Ave., Flushing, L. I., N. Y.

S-69 VOLTAGE-REGULATED POWER SUPPLY. 2-page bulletin illustrates and describes maker's "Model 245" voltage-regulated power supply for industrial and research use; lists specifications; gives operating ranges.—Kepco Laboratories, Inc., 149-14 41st Ave., Flushing, L. I., N. Y.

S-70 MULTIPLE POWER SUPPLY. 2-page bulletin describes and illustrates maker's multiple power supply; covers features, specifications, principles of operation.—Kepco Laboratories, Inc., 149-14 41st Ave., Flushing, L. I., N. Y.

S-71 "THE OSCILLOGRAPHER." 20-page Vol. II, No. 4 issue of this house organ features articles on maker's "Types 304-H, 304" cathode-ray oscilloscopes and maker's illuminated data card for use with "Type 27-A" oscillograph-record camera.—Instrument Div., Allen B. Du Mont Labs., Inc., 1000 Main Ave., Clifton, N. J.

S-72 FLUID PRESSURE CELL. 2-page Bulletin 306 (supersedes Bulletin 270) illustrates and describes maker's "SR-4" fluid pressure cell; includes wiring diagram, cross-sectional sketches, complete specifications.—Testing Equipment Dep't, The Baldwin Locomotive Works, Philadelphia 42, Pa.

S-73 LOAD CELL. 2-page Bulletin 307 describes and illustrates maker's "Type C, SR-4" load cell; lists advantages, uses; gives complete specifications, cut-away drawing.—Testing Equipment Dep't, The Baldwin Locomotive Works, Philadelphia 42, Pa.

S-74 CALIPER. 2-page bulletin describes and illustrates "Mauser Vernier" precision caliper for measuring outside, inside and depth; lists features, improvements.—George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.

S-75 INSTRUMENT TRANSFORMERS. 12-page Bulletin B-4319 illustrates and describes maker's complete line of instrument transformers; discusses construction, features.—Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

S-76 INTERVAL TIMERS. 2-page bulletin pictures and describes maker's "Models 179, 180 GraLab" double-range interval timers; gives features, dimensions, range.—Dimco-Gray Co., 207 E. Sixth St., Dayton 2, Ohio.

S-77 LIQUID SHOCK ABSORBERS. 2-page bulletin illustrates and describes maker's "Heyden" liquid shock absorbers and excess pressure eliminators; lists features, uses, dimensions, prices.—R-S Products Corp., 4530 Germantown Ave., Philadelphia 44, Pa.

S-78 INSULATION TESTERS. 8-page Bulletin 21-46 describes and illustrates maker's "Megger" rectifier and dual-operated insulation testers; covers applications, features, weights and dimensions; gives facsimile scales, specifications.—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.

S-79 TELEMETERING AND RECORDING SYSTEMS. 4-page bulletin illustrates and describes maker's "Metrotype" systems for measuring and recording in numerical tabulated form items on production, quality of process or product; gives applications, advantages, specifications.—Metrotype Corp., 525 W. 76th St., Chicago 20, Ill.

S-80 SMALL SILVER-TYPE STORAGE BATTERIES. 4-page bulletin describes and illustrates maker's "Silvercel" storage batteries; lists models, advantages; gives comparative curves.—Yardney Electric Corp., 105-107 Chambers St., New York 7, N. Y.

S-81 SYNCHRONOUS CAMERA. 2-page bulletin pictures and describes maker's "Model III" 16-mm. synchronous camera; lists features, specifications.—Flight Research Engineering Corp., P. O. Box 1-F, Richmond, Va.

S-82 AUTOMATIC RECORDING COUNTER. 4-page bulletin illustrates and describes maker's "Model PVR" printing stroke counter; gives features, specifications, operation and printing form data.—Durant Mfg. Co., 1997 N. Buffum St., Milwaukee 1, Wis.

S-83 AIRCRAFT INSTRUMENT CATALOG. 188-page cloth-bound catalog, priced at $5.00, illustrates and describes maker's aircraft instruments (accelerometers, airspeed indicators, altitude instruments, direction indicators, pressure gages, tachometers, synchroscopes, etc.); covers application, operation and performance characteristics, installation instructions, principles of

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S-84 "WACO CATALYST." 32-page Vol. VIII issue of this catalog illustrates and describes various maker's laboratory supplies (balances, controller pyrometer, pH meters, voltage regulators, spectrophotometers, titration assembly, and other chemical laboratory supplies); lists features, dimensions, prices.—Wilkens-Anderson Co., 4525 W. Division St., Chicago 51, Ill.

S-85 MINIATURE BALL BEARINGS. 8-page Catalog 49 illustrations and describes maker's miniature ball bearings ranging from 0.1250 to 0.3750 in. outside diameter; gives features, typical applications; covers design factors, variations.—Miniature Precision Bearings, Inc., Keene, New Hampshire.

S-86 ELECTRICAL INDICATING INSTRUMENTS. 12-page booklet describes and illustrates problem, solution, and final result of maker's "ruggedization" developments for electrical indicating instruments.—Marion Electrical Instrument Co., Manchester, N. H.

S-87 HEAVY-DUTY MECHANICAL COUNTERS. 6-page Bulletin No. 3149 describes and illustrates maker's complete line of heavy-duty mechanical counters (standard tripped, motor driven, ticket printing, automatic stopping and explosion proof units).—Richardson Scale Co., Clifton, N. J.

S-88 "SPECTROGRAPHER'S NEWS LETTER." 4-page Vol. III, No. 3 issue of this house organ features articles titled "Production Control Quantometer," and "Why Selected Tubes at Extra Cost."—Applied Research Labs., 4336 San Fernando Rd., Glendale 4, Calif.

S-89 "USES UNLIMITED." 2-page Vol. 6, No. 1 issue of this house organ contains items on maker's new hermetically-sealed switch, rotary-actuated switch, line-voltage pendant switch, etc.—Micro Switch, Freeport, Ill.

S-90 MERCURY THERMAL SYSTEM. 2-page bulletin describes and illustrates maker's 1200 F. mercury thermal system for use on maker's standard indicating, recording or controlling instruments; gives features, applications, ranges.—Taylor Instrument Cos., 95 Ames St., Rochester 1, N. Y.

S-91 SPECTROGRAPHIC OUTFITS. 12-page Catalog H-1 illustrates and describes Hilger & Watts, Ltd. prism spectrographs; discusses process of spectrochemical analysis; covers complete technical data for each type; lists advantages; also covers accessories and source units.—Jarrell-Ash Co., 165 Newbury St., Boston 16, Mass.

S-92 RECORDING THERMOMETER. 4-page bulletin describes and illustrates maker's "81JM120" refrigerated-truck recording thermometer; covers features, advantages.—Taylor Instruments Cos., 95 Ames St., Rochester 1, N. Y.

S-93 "THE OHMITE NEWS." 2-page Dec. '49 issue of this house organ contains articles on maker's industrial resistor assortments,

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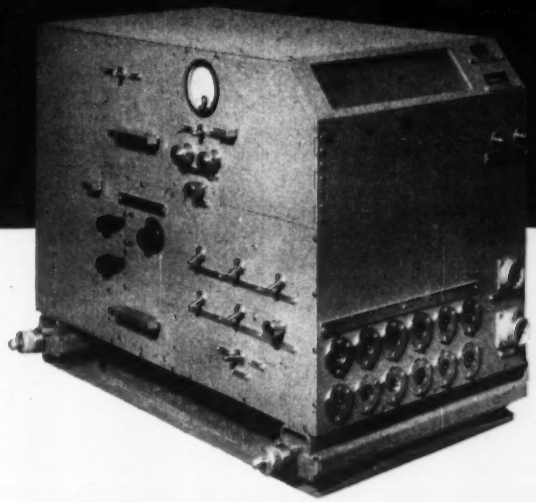
STRESS — STRAIN ANALYSIS

where any or all of the above information is an important factor.



FEATURES

1. 12—50 individual channel recording.
2. Continuous recording up to 200' without jamming
3. Instantaneous changes of recording speeds up to 50" per second with automatic adjustment of lamp intensity.
4. Timing System — Discharge lamp controlled by temperature compensated tuning fork providing sharp .01 second with heavier .1 second timing lines. Conversion to .1 second lines only, by switching.
5. Independent optical system provides constant view of traces with optimum light intensity at all times.
6. Recording lamp under constant surveillance of external condition indicator lamps.
7. Galvanometers — with optional range of frequencies and sensitivities.
8. Electrical — Available for operation from option of 12 or 24 volts D.C., or 110 volts A.C.

OPTIONAL FEATURES

1. Trace identification by means of light interruption.
2. Trace scanning for observation of steady state phenomena.
3. Remote control unit.
4. Automatic record numbering system.
5. Automatic record length control.
6. Visual paper footage indicator.

For additional information write

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